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Guarantees.

People who have machinery to purchase will find a great deal of information in a decision of the U. S. Circuit Court of Appeals for the Colorado district in four suits between the General Electric Company and a mining company and its officers. It seems that the mining company asked the General Electric Company the price of an electrically driven pump to lift 300 gal. of water per minutes to a height of 350 ft. The General Electric Company replied that it assumed a standard stationary pump was required and would take the matter up with the makers of such machines. A few days later it quoted prices on a motor and rheostat made by itself and three different types of pumps made by another company. One of these outfits was ordered by the mining company, it was built, tested and installed at the mine. It broke down so often in the pumping end that much trouble was caused. The mining company refused to pay for the outfit and was accordingly sued for its cost. The mining company endeavored to prove that the failure of the pump to work satisfactorily had caused it the loss of considerable sums which were advanced as counter-claims to the suit of the General Electric Company. The various suits, 141 Fed. Rep. 551, became mixed up in a way that it is of no general interest to follow, because the decision of the Circuit Court of Appeals can be understood without following all the turnings of the legal combatants.

In the contract the only express warranty, which in reality was a condition and not a warranty, was that the pump should have "a capacity of 300 gal. per minute against a head of 350 ft." and should be of a specified make. For one reason or another, however, it could not be run continuously at a rate exceeding 120 gal. against the stated head without breaking down. The purchasers claimed that there was an implied warranty in the contract that the pump could be operated for the usual lifetime of such machinery and would last for such a period, and because it did not do so the contract was broken and they were not liable for payment. In other words, the description of the capacity was claimed to be a warranty of performance, efficiency and endurance. The court ruled that this claim was without foundation. While a manufacturer ought to know the designs, materials and workmanship of the machines he produces, a trader in them, who has no connection with their manufacture, is chargeable with no such knowledge, the court stated, and for this reason contracts of sale made by manufacturers are construed more strongly against them than are those made by dealers.

The court was specific in its declaration that a contract should have a natural and rational construction, if possible, in accord with the course usually pursued under like circumstances, rather than one that is contrary to the customary action of men in similar situations to that of the contracting parties. It is decided to be unreasonable to suppose that a trader who is selling to a customer by description a machine of known manufacture, which the latter selects and the former purchases or orders for him, would guarantee that the article purchased would endure and do the work of similar machines as long as articles of that character ordinarily last. Such an obligation is out of proportion to the consideration which the dealer obtains from the sale, out of the ordinary course of business, and it should not be imposed upon him unless clearly expressed in the contract. The conclusion of the court is that a contract by a dealer to furnish to a purchaser a definite pump of known manufacture, having a capacity of 300 gal. per minute against a head of 350 ft., which has been selected by the purchaser and is to be built by the manufacturer, is not a warranty of the efficiency, performance or endurance of the machine, but rather a description of the pump, like the name it bears, and it is limited in its effect as a warranty to the quality of size.

While this feature of the litigation is of unusual interest, a still more instructive lesson is to be drawn from the court's ruling concerning the contract. It is pointed out that the contract was in writing and embodied an express warranty of one of the qualities of the pump essential to its fitness. Where parties have deliberately put their engagements in writing in such terms as impart plain legal obligations, it is conclusively assumed that the whole engagement of the parties and the manner and extent of their undertaking are embodied in the writing. The exaction or acceptance by the purchaser of personal property of a warranty of one quality is held conclusive presumption that he did not desire, or could not secure, or the parties agreed that he should not have, the warranty of others of the same character. In this case the court points out that there was no implied warranty of the fitness of the pump to do the work for which pumps of its nature are designed, and there was no breach of the express warranty contained in the contract. In view of this clear statement by the federal court it is to be hoped that engineers and others purchasing materials will see that their contracts are so drawn that no question can arise as to what they expect to obtain.

The National Fire Protection Association.

The National Fire Protection Association held its annual meeting in Chicago last week and very properly indulged in modest self-congratulation on the good work accomplished in its ten years of existence. From a membership of twenty in 1897 it has grown until its roll call now numbers over a thousand names, a large proportion of whom are engineers or men of technical education. Its secretary distributes annually to the members over a million books, pamphlets and other publications relating to fire protection subjects, while the committee work and the annual meetings are furnishing invaluable data concerning the methods of construction and the apparatus required to prevent losses from fire. The total annual waste of money by fire reaches such an enormous sum in this country that the work of the Association deserves the heartiest support. Our cities are large, thanks to excellent means of local transportation, our use of frame buildings is extensive, and our municipal regulations concerning the construction of buildings liable to destruction by fire are so lax that the fire-protection problems of this country have fallen to a large extent into the hands of the representatives of insurance companies. Consequently this Association of the engineers and construction specialists who are engaged in determining what is good construction from a fire-resisting point of view and what is good equipment for fighting fires in buildings and industrial plants is doing a work of high value, a work so important that in a country like Prussia, where a more paternal government exists, it is largely done by public officials.

The great merit of the Association's work lies in the fact that it is based on experience tempered by theory rather than the contrary. For example, take its method of investigating the fires in what are called sprinklered risks. This work is in charge of a committee, which tabulates the records of all such fires, about 4,800 cards being already filled with such data. By the use of cards of three different colors the records are classified among fires where the sprinklers extinguished the flames, fires which were held in check by the sprinklers, and those where the sprinklers gave unsatisfactory service. In addition this card index is subdivided by guide cards into about a hundred classes on the basis of the use of the buildings where the fires occurred. The data accumulated in this way furnishes invaluable information concerning the protection needed for different classes of occupancy and also concerning the character of sprinkler installations. They show, for example, that defective, obsolete or incomplete sprinkler installations with light water pressure or defective supplies account for about one-third of the failures and that water supplies shut off or crippled by freezing account for another third. But better than all, these records, collected by men who know what data are useful and how to get them, show that practically all of the troubles with sprinklered risks can be remedied. Given a standard sprinkler equipment, a good building, ordinary occupancy and a proper maintenance of the system, and the chance of a loss is practically eliminated, so far as internal fires are concerned.

The technical methods of the Association are well indicated by the work of the Association in the matter of cement for building construction, a subject which is in the hands of a special committee. It is associated in the investigations of the Structural Materials Testing Laboratory at St. Louis, and also conducts investigations in the Underwriters' Laboratory at Chicago. Not so long ago there was considerable uncertainty as to the quality of materials and workmanship entering into a concrete structure, and as the fire loss on a building is strongly influenced by these factors the Association was accordingly compelled to give particular attention to concrete construction. The committee reports gratifying progress and states that the average concrete building is probably much less open to criticism and is a correspondingly better fire risk to-day than a few years ago. Nevertheless there are a number of features connected with them that must be improved before they are equal to the claims made by over-enthusiastic advocates. For instance, concrete blocks are regarded as open to considerable doubt at present, and until that doubt is settled the Association considers it the part of wisdom to be thoroughly conservative. The committee has found some blocks apparently equal in fire resistance to limestone, while many others were porous and weak and some actually disintegrated in the course of a few months while waiting for the test. The blocks are also open to question concerning their resistance to high temperatures, on account of their form; experience in actual fires and experimental tests show that the shell of the block exposed toward the fire will crack away from the others which are more protected. These and other considerations lead the committee to believe that it will be at least a year before sufficient information is obtained concerning the character of commercial concrete blocks to enable a standard for them to be prepared. In the same way, the subject of reinforced concrete construction must be held open for thorough discussion for some time, for it is not considered possible now to classify correctly the relative fire resistance of concretes made of various materials and different proportions. Moreover, the influence of workmanship is very great on the character of the structure, and the preparation of standard requirements for workmanship, which shall be just and yet effective, is a difficult undertaking. For this reason the committee is unwilling to do more than report progress for the present, and advises the use of the reinforced concrete requirements of the building code of the National Board of Fire Underwriters until more detailed regulations can be drawn.

Another feature of the work of the Association which makes it of much help to the owners of buildings is its examination of the quality of supplies for fire-protection purposes. For example, pumps, valves, fire extinguishers, hose and other equipment are kept under constant surveillance and the requirements for them are modified whenever there has been an improvement in the art. In some case, indeed, these requirements have been placed in advance of the state of the art at the time they were issued, but it is an instructive commentary on the reasonable character of the rules that they have always been met. A year or so ago, for example, new requirements for rotary fire pumps were issued, which aroused considerable opposition from manufacturers, but they are now being met by any maker who cares enough about the business to improve the quality of a portion of his ordinary output to meet this particular demand. In these days of keen and occasional unscrupulous competition, it is an excellent thing to have this unbiased and constant supervision over the quality of materials intended for fire protection, for it makes it much easier for the purchaser of small quantities of such materials to secure reliable goods at reasonable prices.

Vacation Practice.

A good many engineers grumble because young men just graduated from technical colleges do not know much about the actual working methods employed in the office or field. The fact that these young men have never been in a position to acquire such information is overlooked; the critics expect too much. Technical colleges are not trade schools; their students are not allowed to waste their time in learning office and field methods that can be better acquired when engaged in practical work. The colleges are doing better when teaching the science of engineering than when imparting minute instruction in its elementary applications. Nevertheless it is perfectly true that at least six months must be spent by a graduate in acquiring the practical viewpoint, before he can begin to be of much use to his employer, before he can think practically as well as theoretically. It is necessary to put him in the right environment, and the earlier he is associated with the daily work of engineers the sooner will he appreciate the value of his college studies. It is so important for these young men to acquire early this practical point of view, that The Engineering Record urges its readers who are able to do so to offer undergraduates an opportunity to work under them during the coming long summer vacation. It will give the young men an opportunity to look closely at the bottom of the ladder they are aspiring to climb; it will fit them to carry forward their studies to better advantage, and it will makes them more useful assistants after they are graduated. In short, the engineer helps himself while he is helping the undergraduate.

The student at a technical school is likewise urged to employ his long vacation in some practical way. In the case of many it would not be wise to enter an office, for a couple of months in the free air will be better for them physically. Fortunately, the best thing for a technical undergraduate physically is also best mentally, an engagement on some surveying party or construction force. He will learn the importance to an engineer of the ability to superintendent men skilfully. He will appreciate the troubles of field work and the necessity of planning with a view to construction methods as well as to theoretical considerations. He will see why money is often saved by making some things stronger than good engineering requires. He will probably be surprised to observe how little respect is paid to some of his pet theories and how much to other things he has not ranked high. He will have a chance to learn that a good cook is more useful in getting work out of a field party than any other one factor, and he will doubtless be shocked to see how many field problems are solved by drawing instruments instead of mathematical feats. He will be disgusted at being beaten as a draftsman by an illiterate boy and as an instrumentman by somebody who never was inside a technical college. He will observe that for weeks at a time his chief has no occasion to use any technical knowledge, and he will at last come to recognize that, as the engineer's occupation is fundamentally spending somebody's money economically, he must learn to think in dollars as well as cosines. Very few men become good engineers who do not have construction experience, and as it is a good, healthy life, almost entirely different from college work, The Engineering Record has no hesitation in recommending its readers in undergraduate circles to try it during the coming vacation. Young men old enough to attend technical colleges are old enough to get out of the habit of regarding several months' entire freedom from responsibility as necessary for their well-being; what they need is a change of surroundings and open-air experience, such as field work affords.

The Reported Decadence of London as a Manufacturing Center.

The British engineering papers have recently contained some interesting comments on the alleged decadence of manufacturing in the London County Council area. Some of these publications ascribe the change to the baleful effect of the London County Council on the general prosperity of the district over which it holds sway, while others are disposed to admit more natural and less political influences may have operated to produce the existing conditions. The facts seem to be that there is about twice as much vacant property now as there was but a few years ago and that when a factory building is vacated at the present time its rental value is immediately reduced about one-half. Whether this depreciation is owing to the limitations of the building regulations of the London County Council, to the changes required to make the building suitable for a new tenant, or to other causes is a problem which only a careful investigation of the facts of each case will solve. With all respect to the authorities who see in the decline only the results of the blight of incompetent government, it must be said that natural municipal tendencies will probably account for much of the alteration.

In the first place, it may be questioned whether London is really declining as a manufacturing center. The production of a host of fancy wares of high value and small size is best conducted in cities, for in no other place can the workmen, materials and market be found so closely associated. It would be interesting to know the conditions in such trades. While one class of manufacturing may become too inconvenient or too expensive in a large city, another class may develop to take its place. While the change is taking place there will, of course, be vacant premises. There will also be periods of stagnation while an industry is finding a new center after being driven from its old location. This is more difficult to determine in London than in New York, for example, because wages are so much higher here and local transportation facilities are so much better that it is less important to consider the housing of the working people in the vicinity of the proposed new site. In fact, it is only in the case of shops employing women and likely to run nights at some seasons of the year that much attention is paid in New York to the labor market. In London, on the contrary, this subject is understood to be much more important. Consequently the change in the character of the manufacturing done in a locality must be more gradual in London than in New York.

It is perfectly true that when a manufacturing establishment attains large size, when its quarters become cramped and it is unable to extend its buildings, it will move to a less crowded locality. This happens also for many other reasons than poor municipal policy. In the United

States it has taken place on account of the reckless exactions of labor unions, as at Chicago; the lack of avaialble room, as in Pittsburg; the rapid demand for land by interests able to pay higher rentals than heavy manufacturing undertakings can carry, as in New York; the desire of the owners of such works to get out into the country, where their employees can have the benefit of better living conditions. The assertion that an increase in payments for taxes is an indication of poor or extravagant government which is driving manufacturers away is rarely warranted. The expenses for legitimate municipal improvements and for conducting the necessary branches of municipal government increase with the growth of a city. As a city grows there will always be portions of it which change their character, and during this change the property in the district will yield a lower return. This seems to be the case with some of the districts in London which formerly were occupied by heavy manufacturing and are now being slowly vacated in favor of localities where land is less expensive and shipping facilities equally good. It is but natural that these vacant premises should be less profitable to their owners for a few years until a new class of tenants is established in the district. The condition can be observed in any large city, and London is probably no more losing ground as a manufacturing center than is New York because a number of big companies have recently left it.

There is always a natural tendency for people engaged in one line of business to consider that all other lines are affected in sympathy with it. This may be true as regards general trade conditions, but it is doubtful if it is correct with respect to such conditions as the location of manufacturing establishments. The influences that render business difficult for one company in a city to conduct its business are more likely to affect other companies in the city in the same business than in others. Just now the situation in London seems to be such that the engineering trades find it advisable to move, but a more complete statement regarding all trades is necessary to carry conviction that the world's metropolis is losing any manufacturing business that rightfully belongs to it.

The Sea Level Plan for the Panama Canal.

The recent vote of the Senate Committee on Interoceanic Canals in favor of the sea-level plan for the Panama Canal is a result of much significance. While it is but one step in the procedures leading to the final selection of type, it demonstrates beyond question that not only sentiment in the Senate, but also widely extended public opinion has been making substantially for the sea-level plan recommended by the Board of Consulting Engineers. In view of the growing favor of this plan, it is scarcely too much to say that the vote of the Senate committee probably insures a sea-level canal across the Isthmus, indeed, the sea-level sentiment of the Senate is so strong that it is commonly believed in well-informed quarters in Washington that the President himself is again considering whether the favor of the public toward that plan may not necessitate its adoption.

This condition has been brought about by the intrinsic excellence of the plan as advocated by the Consulting Board, and as further brought out by the comprehensive and thorough examination of every detail of the whole problem by the Senate Committee. Probably no member of that committee has done more effective service in bringing out both the strong points of the sea-level plan and the weak points of the lock plan than Hon. A. B. Kittredge, Senator from South Dakota. One of the strongest parts of the evidence, due especially to Senator Kittredge, is the letter addressed to him by Mr. William H. Hunter, chief engineer of the Manchester Ship Canal and a member of the Board of Consulting Engineers. This letter, printed elsewhere in this issue, contains a most forcible statement of Mr. Hunter's views, especially as to the grave dangers of operating the six great locks of the high-level plan, particularly the three locks in series proposed at the Gatun dam near Colon. He sets forth the results of five serious accidents to lock gates on the Manchester Ship Canal between April, 1895, and January, 1906, in all of which lock gates were either wrecked or carried away with serious consequences. He shows conclusively that the measures of partial protection proposed would, in fact, be practically no protection at all, as "in each case in the foregoing list, except the first, the vessel had actually entered the lock in safety . . . her mooring ropes had been passed out on to the lock walls and . . . she had therefore proceeded beyond the point at which the 'long pier' would render undoubted assistance in the navigation of vessels where approaching a lock." These accidents on the Manchester Canal narrowly escaped from resulting in destructive disasters, but there could be no hope of such escape with the greater locks and much greater lifts of the Panama plan. He considers the proposed group of three locks at Gatun "as presenting one of the most striking examples of rash and hazardous experiments in the construction of public works ever seriously suggested to the government of a great nation."

Mr. Hunter expresses an equally emphatic judgment on the proposed earth dams of the high-level plan which he considers "of an almost equally hazardous character." On this point there may be room for much legitimate difference of opinion, but in view of the uncertain character of the information disclosed by deep borings and of the extensively water-bearing character of the material penetrated at the Gatun dam site, it is undoubtedly prudent to avoid great earth dike constructions, however valuable for other conditions, in the manner proposed for Gatun, if types of construction approved by longer experience are available. It is of real importance to a fair and complete discussion of the questions to find these positions held by the American members of the majority of the Consulting Board confirmed by such an eminent specialist in lock canal construction, operation and maintenance as Mr. Hunter.

Other portions of his evidence regarding the peculiar character of the lake and other channels proposed by the minority, is highly interesting, and they confirm fully the strong position taken before the Senate Committee by the American members of the majority in giving their evidence. Especially is this the case in his emphatic statement based upon his prolonged experience in canal navigation, that "no widenings of the canal prism for passing places will be required," and except "with vessels of the very largest dimensions . . . no vessel will be moored with the mere purpose of allowing another to pass her. When steamers meet both will slacken speed somewhat and so will pass each other without difficulty or danger."

The time required for the construction of a sea-level canal, one of the disputed features of the work, is surprisingly settled by a remarkably significant statement in the special report of the chairman of the Isthmian Canal Commission, printed in this journal last week. Mr. Shonts states that Chief Engineer Stevens "believes that by July or August he will have 40 (steam) shovels installed, and will be in a position to remove approximately 1,000,000 cu. yd. per month." This passage relates to work in the Culebra Cut, and the rate named by the chief engineer is to hold for July or August, i. e., in the heart of the rainy season. Inasmuch as not less than eighty or one hundred steam shovels may readily be worked in the Culebra Cut, Chief Engineer Stevens appears ready to guarantee the removal of 2,000,000 cu. yd. of material per month during the rainy season, or at a moderate computation of not less than 24,000,000 cu. yd. per year. This would take out the entire Culebra excavation required for the sea-level canal in less than five years. Since the Consulting Board based its estimate of time for completion for the sea-level plan at a maximum annual excavation of 20,000,000 cu. yd. only, it is thus seen that Mr. Stevens has placed himself in advance of the position of the sea-level advocates. Possibly the present commission is preparing to endorse the sea-level plan, for these figures, taken from the special report of its chairman, certainly indicate that the plan can be executed within a period of time at most no greater than that required by the lock plan.

When these considerations are coupled with those connected with the appaling earthquake disaster at San Francisco, there is little left for a lock plan advocate to stand upon. Such a severe earthquake as that which recently visited the California coast would almost certainly put a lock canal out of commission by deranging the gates, and would with almost equal certainty leave a sea-level canal practically uninjured, even if a tidal lock should be built at the Panama end.

The Purity of the Water Supply of the Boston district has been threatened by a bill recently introduced in the Massachusetts legislature to permit boating on the ponds of the Metropolitan water-works. It is probable that a great many people have looked with longing eyes on these beautiful sheets of water for they would be delightful places for boating and fishing. Such amusements should not be tolerated, however, on any pond which furnishes a water supply for potable purposes. If it is permitted to one it must be permitted to all, and the water would inevitably become contaminated. When municipalities are spending large sums to acquire control of the land bordering these reservoirs in order to keep people away from the water, it is surely not the time to allow everybody to use boats on them without further formality than procuring a license.

The Cape Cod Ship Canal project is now showing signs of considerable activity. The Boston, Cape Cod & New York Canal Co., a Massachusetts corporation about seven years old, recently filed plans for the work with the State Harbor Commissioners. These differ somewhat from the plans presented five years ago and embody suggestions made by the Commissioners. Conferences have been held at which Dr. E. L. Corthell and Mr. William Barclay Parsons appeared as the company's engineers, and it is understood that plans for carrying the canal across the New York, New Haven & Hartford R. R. are now being developed. This undertaking is one of such usefulness to coastwise shipping that its resumption of life is decidedly encouraging. The same cannot be said, however, for the proposition to construct a canal from Fall River through Weymouth, Taunton and Brockton to Boston. The cost of the waterway, if made large enough for coasting vessels, would be a prohibitive burden on its commercial success, while a little canal would not have enough business to warrant spending any money on it. There is a sound commercial basis for the Cape Cod Canal, but none can be discovered for the Boston and Fall River project.

THE STRUCTURAL, MUNICIPAL AND SANITARY ASPECTS OF THE CENTRAL CALIFORNIAN CATASTROPHE.--I.

A Statement of Conditions Produced by Earthquake and Fire, and Conclusions Drawn from Them.

By Charles Gilman Hyde, Assoc. M. Am. Soc. C. E.

At about 5.13 A. M., April 18, 1906, there began a series of seismic disturbances in Central California, in the region more or less immediately adjacent to San Francisco Bay, which has been attended with more serious consequences than any other natural phenomenon ever occurring, within the history of man, in this section, or perhaps in any other in the United States. It will be difficult to overestimate the significance of the effects produced by the earthquake. It must not be forgotten that the disturbances caused by this seisma were the primary cause of the fire in San Francisco and of the destruction of the mains which would otherwise have furnished water with which to combat the flames. In consequence of the earthquake and its attendant effects, there have arisen a great variety of problems whose nature it is the province of this paper to discuss briefly.

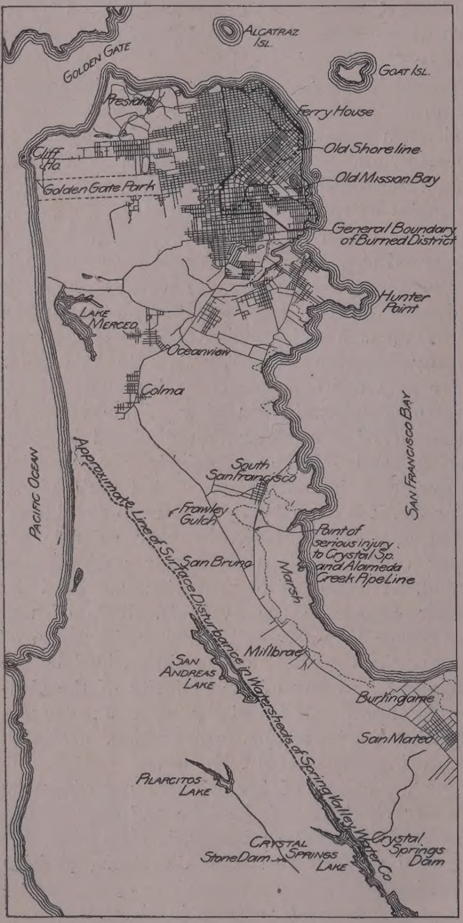
No one who has lived near the region affected by this catastrophe can fail to appreciate the human element in the situation. In the first place many lives have been lost—just how many no one will probably ever know. In comparison with the number of persons whose homes were destroyed, however, the number of deaths is surprisingly small. The great majority of these deaths was due to the destruction by the force of the vibrations of the earthquake, of buildings which were improperly constructed and had no excuse for continued existence. Had the earthquake occurred within business hours, it is safe to say that the fatalities would have been appalling in nature and extent, due not merely to the collapse of buildings but perhaps to an even greater degree to the falling of electric wires, "fire-walls" so-called and cornices of buildings, and many other aerial structural elements of cities whose position is always precarious and is especially such when viewed from the standpoint of disturbance by earthquake.

Earthquakes will surely occur in the future, and it is probable that in due course of time a severe one may take place during the busy daylight hours when the cities are swarming with people and the opportunities for wholesale destruction of life are so great as to be fairly startling. It is very evident, therefore, that the problem here introduced and the entire attendant situation must be squarely faced if life is to be protected at such times in the future.

Aside from the loss of life as one of the saddest results of the recent earthquake, the commercial aspect of the problem demands the attention of the engineer as well as other men of affairs. The actual monetary loss to the community is very great; it cannot now be estimated closely and it is doubtful if it can ever be determined satisfactorily. But this loss is not irreparable. The spirit of the people of this western coast is very remarkable, and it is already clear that they will rise above the present misfortune and will soon efface (so far as is possible) the pitiful results which are now so evident on every hand.

Within the region more or less immediately affected by the earthquake it is probable that on April 18, upwards of two-thirds of a million people dwelt. For this population and probably for many more, San Francisco was the great social, industrial and distributing center. Here were the warehouses and commercial establishments from which the great bulk of supplies, from groceries to electric motors and other machinery, was distributed. For a short time, other places, Portland, Oakland, Los Angeles, will serve as centers of distribution and of manufacture, but a large proportion of these undertakings will return to San Francisco, and all within a period which will doubtless be surprisingly short.

Another aspect of the San Francisco fire concerns very directly the engineer, in common with other professional men. Comparatively few architects, engineers, lawyers, physicians, and others having offices within the burned district, were able to save more than their most important papers. Their libraries, their instruments and apparatus, and in many instances their records accumulated during years of experience, which to them were of priceless value, are gone, and they have become lost to the technical and scientific world. One can hardly appreciate what this means, for instance, to many members of the San Francisco Association of the American Society of Civil Engineers. This article would be seriously incomplete if there were omitted mention of the zeal with which this Association is meeting the public problems presented by the catastrophe. It has officially tendered its services to the city of San Francisco and has organized sub-committees whose duty it is to study the entire engineering situation, in all its various phases, and to report the results of their investigations in such manner as will prove of greatest efficiency and value, not alone to this immediate locality, but to the world at large.



Line of Surface Disturbance.

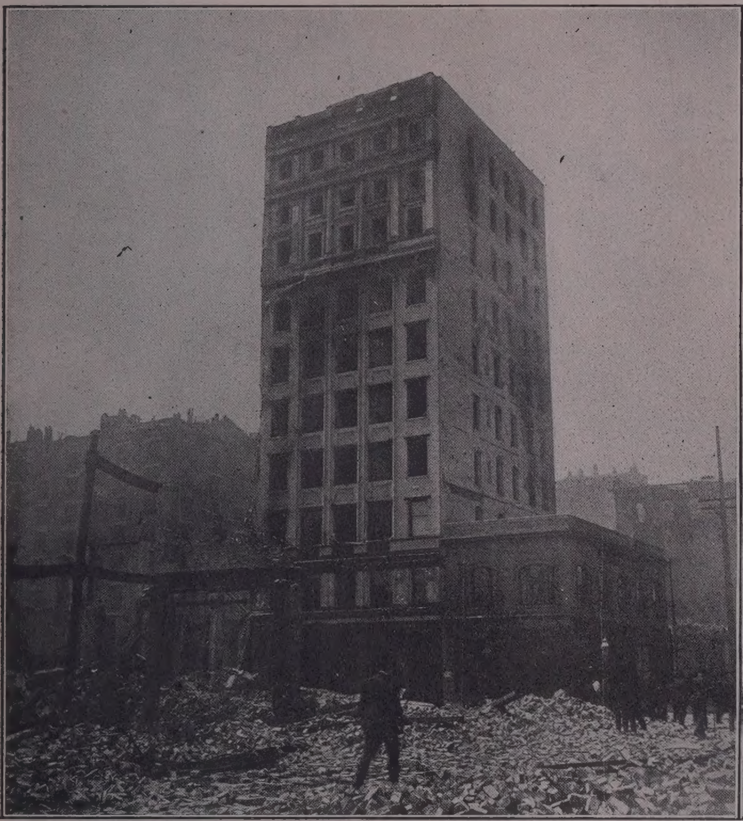
In behalf of the Department of Civil Engineering of the University of California, Prof. Charles Derleth, Jr., and the writer have been undertaking a study of the effects of the earthquake and fire in San Francisco, and in the region of San Francisco Bay from the standpoint of structural, municipal and sanitary engineering. In this work they have been largely assisted by the students in the upper classes in the department. Some of the results of these interesting studies are presented herewith. In this connection it should be said that the conclusions reached must be regarded as preliminary, yet it is hoped and expected that they shall prove to represent the actual conditions very closely.

The Earthquake.—The heaviest shocks of earthquake were felt from 5:13:38 to 5:14:18 A. M., on April 18. The vibrations diminished considerably during the following ten seconds and then continued with renewed vigor for about twenty-five seconds more. Many further shocks of less intensity occurred at intervals throughout this and succeeding days, but practically all of the damage which was caused, was produced within the period of violent disturbance above referred to. It has been stated upon good authority that the rate of vibration was unaccountably slow, and to this fact alone may be attributed the comparatively slight loss of life and destruction of property by the earthquake itself. The direction of the principal vibrations appears to have been from south-southeast to north-northwest. Deductions from the seismographic chart taken from the instrument at the students' observatory of the University of California at Berkeley, on the east side of San Francisco Bay, indicate that the maximum actual linear movement of the earth's crust during the oscillations was in the neighborhood of three-fourths of an inch. The strata at Berkeley appears to be unusually firm. In soft materials, particularly in marsh and filled lands, the oscillatory movement must have been very much more pronounced, but, so far as the writer knows, there are not at present any reliable data on this matter.

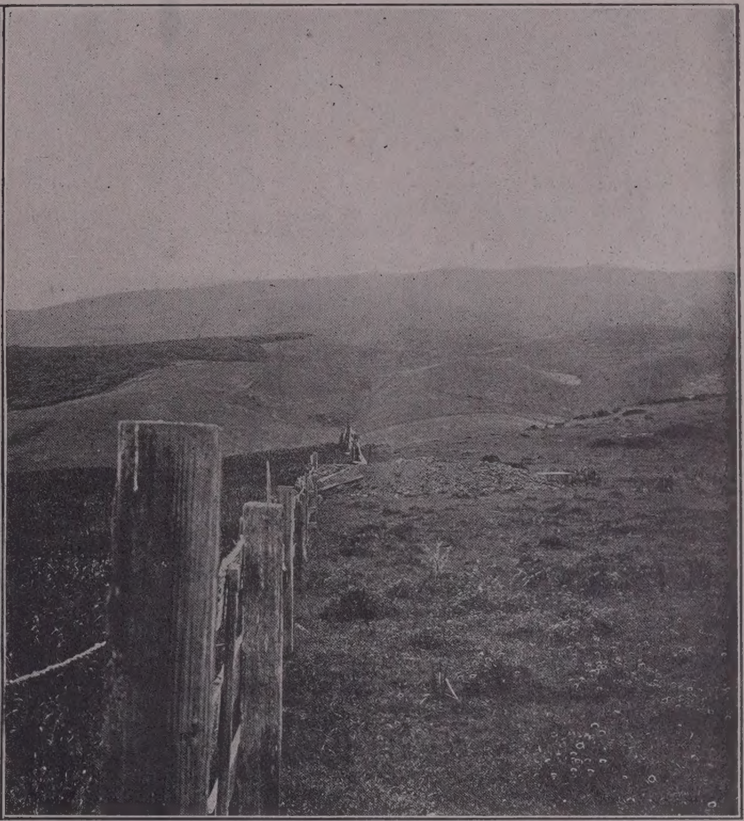
Earthquakes in the region comprised by the State of California have been frequent throughout its period of occupation by civilized man. None of the former disturbances have been attended with any very considerable loss of life, and none appear to have been comparable with that of the current year in force and severity, except perhaps those occurring in the years 1868 and 1871.

The region of maximum disturbance during the seisma of April 18 appears to have been along or near the line of an old fault which has been carefully traced and has been known to geologists for a long time. It is assumed that this fault represents a line of weakness in the strata and it would have been reasonable to expect a re-occurrence in the present instance of some of the phenomena attending the former disturbance. As a matter of fact this is exactly what has happened, and for many miles in the region under discussion the surface strata have been distorted and opened up, and fissures, almost without interruption except where they pass below water surfaces, can be traced from Tomales Bay and Bolinas in Marin County to Salinas in Monterey County, and perhaps even further southward, the general direction being from north-northwest to south-southeast. Through the courtesy of Mr. Herrmann Schussler, Chief Engineer of the Spring Valley Water Company, the writer has been able to trace this line very definitely for a distance of about 14 miles in the northerly portion of the San Francisco peninsula from a point lying 2½ miles south of the southerly end of Lake Merced to the southerly extremity of the South Crystal Springs reservoir. Throughout this region evidence of terrific force is plainly visible and the earth along the line in question has been torn up and in many instances moved longitudinally to a very appreciable extent—in one case as much as 7 ft. This figure is the result of an actual measurement by the writer and was determined by the distortion of a fence line formerly perfectly straight, but now disrupted and the torn ends separated by the distance just mentioned. One of the accompanying pictures is a view at this point, several hundred feet northeast of the extreme northern end of San Andreas reservoir of the Spring Valley Water Co. The pile of earth marks an excavation to the 28½-in. Pilarcitos water main, which was here torn apart 53½ in.

Further than these general remarks it is hardly deemed advisable at this time to discuss the scientific and geological aspects of this most important phenomenon. These are being very adequately studied by the State Earthquake Investigation Committee, of which Mr. Andrew C. Lawson, Professor of Geology in the University of California, is chairman, and Mr. A. O. Leuschner, Professor of Astronomy of the University of California, is secretary. The results of their studies and their conclusions will be made known in due time and will prove of the greatest scientific value and interest.



Atlas Building.



View on Line of Fault.

The Structural and Building Problem.—Perhaps in no line of engineering are the effects more apparent and the results capable of more complete and satisfactory study than those which concern the proper construction of buildings to resist destruction by earthquake and by fire. While it is true that within the devastated area of San Francisco, the effects of the earthquake have been largely obliterated by the fire in the case of all structures except those representing the very best types of construction, there are, nevertheless, still in existence outside this area a sufficient number of representative examples of these poorer classes to prove very conclusively their merits or disadvantages; unfortunately, mainly the latter. As the combined result of the earthquake and the fire, it is stated that there now remain in the burnt district of San Francisco but thirty structures which it is thought may be in a sufficiently satisfactory condition to become a part of the new city which is to rise out of the ruins of the old. In conjunction with Prof. Derleth, the writer has been enabled to examine more or less closely the majority of these structures. Perhaps in no other way can the effect of the earthquake and fire upon the different classes of buildings be indicated more clearly than by describing some of those which have been examined in the rather superficial manner stated. It must be understood that the real effects can, in many cases, only be learned by a very careful, painstaking study, involving the stripping of the protective coatings surrounding the steel work, and by an adequate testing of the materials actually found in the columns, floors, and other parts of the structures in question.

So far as the writer knows there is no other case of a recent general fire in any city where the water supply during nearly the entire conflagration was absolutely cut off and not one drop was available with which to fight the flames, except on the water front. It does not appear, therefore, that there would be a more severe fire test for buildings than that given within the burned district of San Francisco. If this is true, as it evidently is, there must now be a very unusual opportunity to pursue a scientific study of the fire-resisting qualities of present-day structural materials and of the methods of design to resist injury by heat.

For the purposes of the present discussion, therefore, the writer has separated the principal structures examined by him into several distinctive types or classes, leading examples of each of which will be later described:

1. "Class A" buildings, with suitable foundations, complete steel frame, and having all exterior and interior walls supported entirely by steel work; constructions throughout "fireproof."
2. "Fireproof" structures with steel framing and other features like Type 1, except that the exterior walls are supported by the foundations.
3. Brick or other masonry structures (including reinforced concrete) involving heavy exterior and interior walls, all thoroughly bound together by masonry anchorages and by longitudinal steel reinforcements.
4. Masonry structures with interior unprotected steel work, or with the so-called "slow-burning mill" construction, and having no efficient lateral stiffening or support for the exterior walls.
5. Wooden buildings.
6. Masonry chimneys.
7. Bridges.

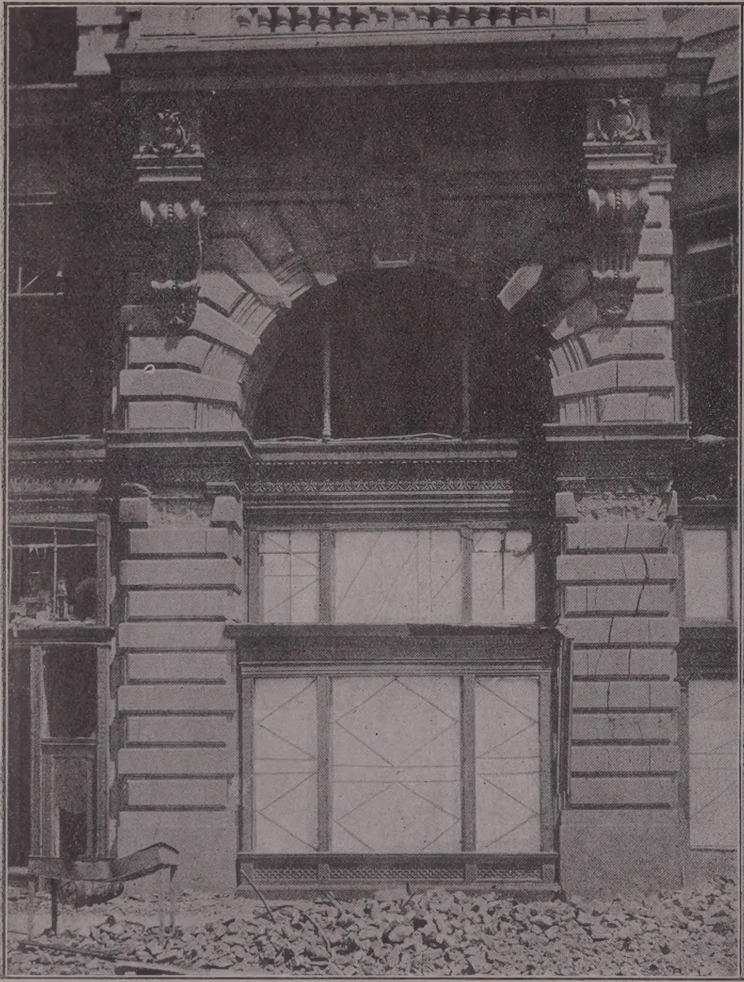
Type I.—Under the Building Laws of San Francisco operative before April 18, "Class A" buildings were designated as those which were provided with complete steel framing supported upon foundations adequately adapted to the peculiar conditions affecting each structure and each location. The spandrel walls are supported wholly by the framework, and their weights are carried to the columns by the horizontal steel members. The whole construction is of the so-called "fireproof" design. The most notable buildings of this class, fulfilling the above requirements, will be briefly described.

Atlas Building.—This building is a 10-story structure on Mission St., near Second. An accompanying view shows its south and east walls. So far as known, its construction completely fulfils the requirements of "Class A" buildings. The effect of the earthquake is shown by the bulging of the brickwork, principally on the east and west faces on horizontal lines near the floor levels. In fact, in some cases, the bricks have been thrown entirely out of the channels at these points. The intermediate brickwork between the stories on the east face shows very marked "X" lines. This building was exposed to a very hot fire on the west and north sides and the furniture and other materials within the building were completely consumed. The interior construction, embracing reinforced concrete floors supported by steel frame work, appears to have been uninjured. The ornamentation of the front face of the building was partly destroyed, and the "sandstone" front was considerably spalled.

This building represented cheap but good construction. The brickwork of the exterior side walls was simply plastered. Wood window frames, doorways, etc., were used.

NEW CHRONICLE BUILDING.—This structure was in the process of erection and comprised 16 stories. It is situated on Kearney St., just north of Market. Its foundation is on sand, and it is understood that some quicksand was encountered. The brick work was badly cracked on the Kearney St. front, in "X" lines, which are typical of the earthquake effects in masonry of this type. The building had little (if any) combustible material within it, and the steel framing, which was still unprotected, seems not to have been exposed to a very hot fire. The real danger to this structure is not yet known, but it is expected that it will be slight.

JAMES FLOOD BUILDING.—This building is located on Market St. near Powell, and a view of its southwest corner is shown in an accompanying illustration. Its construction conformed to the specifications for "Class A" buildings. The exterior walls fronting streets comprise a granite base course, and a sandstone facing above. The other walls are entirely of red brick masonry. The floors are of hollow arch tile, and the partitions are of hollow tile of the usual pattern. Very many cracks appear in the columns at the main entrances of the buildings, at the first floor, where heavy loads were concentrated. There are slight cracks vertically and diagonally near the re-entrant angle of the east wall of brick, especially at the fifth, sixth and seventh floors. The cornice of the building is comparatively light, and seems to have been undamaged by the earthquake. The interior partitions were largely destroyed by the force of the vibration of the temblor. Practically all of the woodwork and furnishings and materials in this building were wholly destroyed by the fire. It is probable that only a full and careful examination will reveal the true condition of the steelwork and the flooring system.



James Flood Building.

Hotel Alexander.

KOHL BUILDING.—This building is located at the corner of Montgomery and California Sts. It probably represents the best type of fireproof construction to be found in San Francisco. The exterior walls on the street fronts are faced with cut sandstone blocks; the remaining walls are of ordinary red brickwork. This building has metal window frames and reinforced concrete floors. Apparently there was very little about this structure, except the furnishings of the rooms, which was inflammable. From the accounts of those who occupied this building, there was apparently no considerable damage occasioned by the earthquake. The building was exposed to a close and hot fire only on the east side, while on the south side a fire of considerable intensity occurred across the street. Fire broke out in the lower floors of this building and the furnishings of the offices in this portion of the structure were destroyed, but on the upper floors very little damage was caused in certain parts, indicating a quality of fireproofing far more satisfactory than that found in most other buildings of this type in San Francisco.

MERCHANTS' EXCHANGE BUILDING.—This building is located on California St. just east of Montgomery. It is a fifteen-story structure, built in general accordance with the "Class A" requirements. It was apparently very little damaged by the earthquake, although the east wall shows some diagonal cracks in the brickwork. On the west wall, pilasters of brickwork fell away from the steel columns in certain places. This building was exposed to a hot fire on three sides, the front on California St. side being less exposed. The fire swept throughout the buildings, but aside from consuming the contents of rooms and the woodwork, it is believed that very little damage was caused to the main portions of the structure. Within a very few days after the earthquake and fire, a barber shop was established in the basement and the boiler plant was in operation, the smoke therefrom issuing from the riveted steel stack anchored to the north wall.

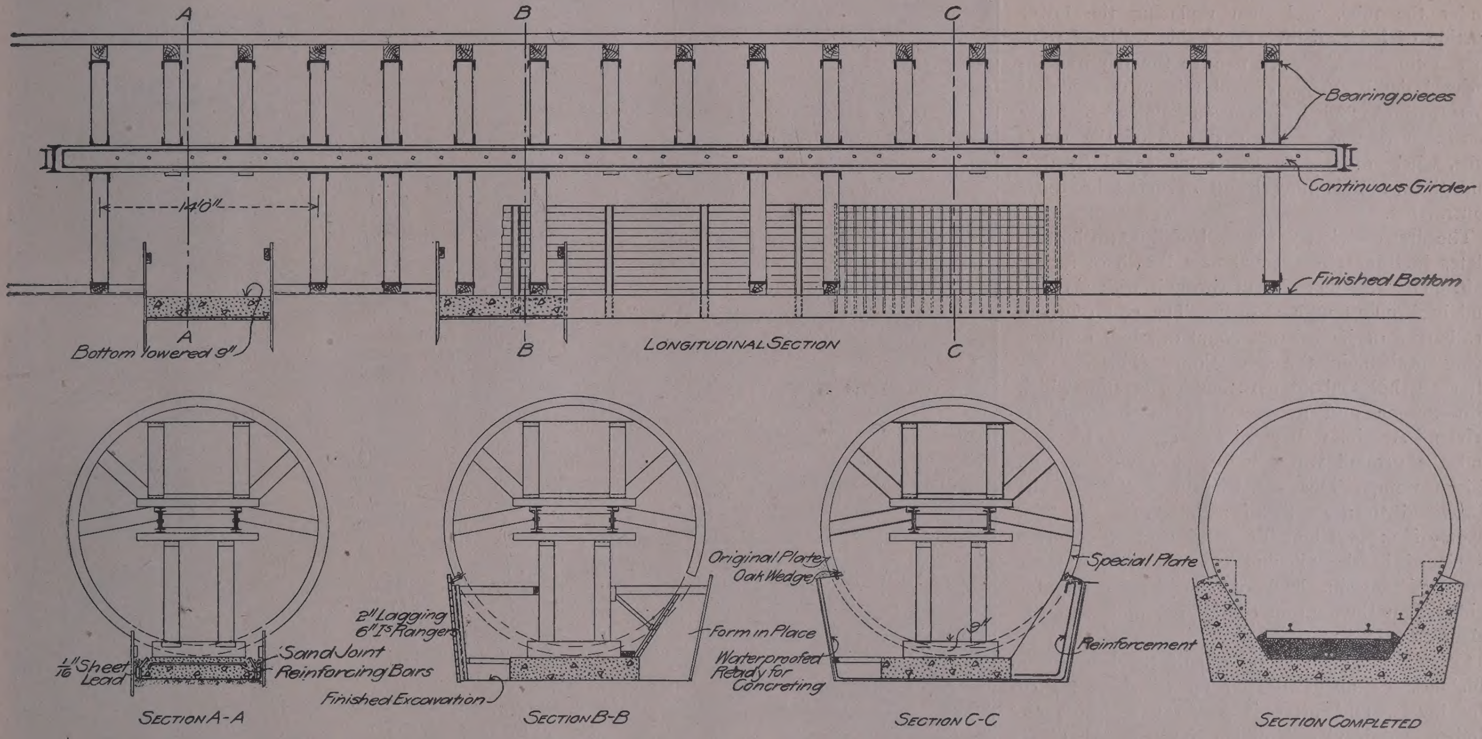
MUTUAL LIFE INSURANCE BUILDING.—This building is located at the southeast corner of California and Sansome Sts., and is one of the high and well-built structures of this class in San Francisco. It appears to have been but very little (if any) damaged by the earthquake. Fire swept through it, destroying the woodwork and the contents of the rooms. Eight days after the earthquake, the debris was being removed from this building, and it was stated that the offices would be opened in a very few days.

ST. FRANCIS HOTEL.—This building is one of the notable structures of San Francisco, and is located on the corner of Powell and Geary Sts. It is a thirteen-story building, having a carefully designed steel frame. The exterior walls fronting on streets are faced with sandstone blocks. The main front of this building was cracked by the earthquake, especially at the left of the entrance on Powell St. The sandstone of the south face, especially in the vicinity of window openings, was seriously spalled by the fire, which swept through the entire building. Very little, if any, inflammable material was left. Serious damage to the interior ornamentation of the building was caused by the fire, and in many cases the ceilings of plaster on metal lathing were torn down and destroyed. It is impossible from a superficial examination of this structure to discover whether or not the steel framing and reinforced concrete floors were seriously injured by fire.

(To be Continued.)

Grade Corrections in the Battery Tunnel, New York.

The subway systems of the New York Rapid Transit R. R. in the Boroughs of Manhattan and Brooklyn will be connected by a tunnel crossing the East River from Battery Park to the foot of Joralemon St. This will include a length of about 6,750 ft. of parallel single-track tubes 26 and 28 ft. apart on centers, with segmental cylindrical cast-iron shells lined with concrete, and having a clear inside diameter of 15½ ft. Between bulkhead lines, a distance of about 4,200 ft., the horizontal alignment has 3.1 per cent. grades united at the lowest point near the center of the river by a vertical curve with a maximum depth of about 94 ft. from mean high water level to rail base. At the New York end, the tunnel is entirely in rock and at the Brooklyn end entirely in sand. In some places under the river, the upper part of the tunnel is in sand and the lower part in rock. The thickness of the roof above the tubes varies from 9 to 50 ft., and the maximum depth of water is 50 ft.



Sketches Showing Method of Rectifying Alignment in the Battery Tunnel, New York.

Tunneling operations were commenced early in 1903, since when the progress has been nearly continuous in all of the four headings, some of which have advanced as much as 240 ft. per month. On May 23, the distance between the headings of the north tube was 890 ft., and the distance between those of the south tube was 999 ft. Most of the remaining distance to be tunneled is believed to be through sand and earth, and it is expected that, barring unforeseen delays, the headings will meet in November and the tunnel will be completed ready for traffic about the first of next January.

All of the excavation and lining has been accomplished under an air pressure of 5 to 34 lb. per square inch, about 30 lb. being now maintained by a 1,000-h.-p. compressor plant at the New York end, and a 3,000-h.-p. plant at the Brooklyn end, which together consume about 100 tons of coal daily. Double air locks are now maintained in each of the tubes with a pressure of about 15 lb. between the locks of each pair. At the New York end the tunnel has been drifted through the rock with top headings and a single bench, without the use of shields. At the Brooklyn end shields were installed at the commencement of the work and were operated in both directions from the foot of the Joralemon St. shaft; one pair of shields advancing under the river to meet the New York headings and the other pair moving in the opposite direction to meet the headings from Section 3 of the road.

The shields are about 17 ft. in diameter and 9½ ft. long exclusive of a 2½-ft. hood. With their fittings they weigh over 100,000 lb. each and are advanced in 22-in. steps, corresponding with the width of one ring of lining, by the operation of fourteen hydraulic jacks with a total capacity of 4,222,000 lb.

In some places the earth was very soft and it was difficult to prevent the settlement in it of the heavy shields, which occasionally deviated from the required alignment. In some cases the settlement was so much that complete control of the shields was lost and irregularity in grade resulted. This was most serious where the shields intersected the ground-water plane and the water level was reduced by sinking well points and pumping just in advance of the shield. This destroyed the equilibrium in the earth, virtually undermining the end of the tunnel tube, and a considerable settlement resulted which extended back some distance beyond the tail of the shield. The Rapid Transit Railroad Commission's engineers maintain a system of accurate levels which are recorded by marks in the tunnel roof and transferred as the tunnel progresses to permanent marks in the bottom of the tube. As each successive ring of cast-iron lining was added the engineers leveled the key segment and recorded its exact position. The amount of deviation from the required grade was thus known and the contractors were notified that the irregularities must be corrected and allowance was made for them in their monthly estimates. It was not, however, considered desirable to delay the progress of the tunnel by making these corrections immediately, as it was known that they could be made as readily without interrupting the work after it had advanced beyond them.

The principal irregularities occur in Section 2A of the fifth division of the work, which extends under Joralemon St. from Clinton St. to the East River. In that portion between Henry and Hicks Sts., 1,000 ft. east of the Brooklyn bulkhead line, the principal irregularities occur. At the east end of this section the ground-water line is at about the level of the invert, at the west end it is 12 ft. above it. The grade here is about 3.1 per cent., and the maximum depth of invert below the street is 63 ft. The soil is coarse sand with some gravel and cobble-stones and a few narrow pockets of fine sand. In the first set of 218 rings, about 400 ft., the south tube has a maximum deviation of 0.8 ft. below the required grade and 0.4 ft. above it. In another set of 93 rings, separated by a distance of 90 ft. from the first set, the bottom is 0.5 ft. too low, and between these two places there are 43 rings in the variation downward of the roof from grade reaches a maximum of 2.4 ft.. In the north tube, about opposite, there are five places having respectively 123, 35, 140, 102 and 73 rings each, in which the variation reaches a maximum of 0.9 ft. below the required grade. In this length 96 rings are so low that the upper part will have to be raised.

Partial reconstruction will, therefore, be required for a total length of about 1,800 ft. in the north tube, and 700 ft. in the south tube. As the precise alignment of the tunnel is arbitrary, it was decided that safety and satisfactory operation would be completely assured by modifying the original grade and allowing the alignment to be changed in these parts. The repairs necessary will therefore consist of correcting the irregularities so as to provide a smooth grade for the tracks and insure sufficient clearance for the cars. This can be done either by elevating the rails above the bottom of the tubes in the depressed places and correspondingly elevating the tunnel roof where necessary, or it can be done entirely by lowering the rails and the bottom of the tunnel to correspond with the maximum depressions. The latter method is considered the easiest, quickest and most economical, but will involve rectification of a greater length of tunnel. Therefore, it is at present intended to combine the two methods and elevate the roof in some places and depress the floor in other places.

Various methods of reconstruction have been considered, among which was that recommended by Mr. Charles M. Jacobs, who proposed to construct an outside shield enclosing the section to be repaired and within it to entirely remove the old tunnel ring and replace it by a new one. This would involve a long delay and an estimated expense of $1,000,000 and was not approved by the chief engineer of the Rapid Transit Commission. Another method was the replacing of the lower half of the tunnel tube by new cast-iron plates extending below the original bottom of the tunnel and changing the cross-section from a circle to an irregular figure with objectionable cusps in the side walls. A third plan was to enclose portions of the tube between transverse diaphragms or bulkhead walls and refrigerate the space between them so as to freeze the wet sand outside, enabling the lining to be removed and replaced under the protection of the frozen earth.

A much simpler method was suggested by Mr. J. C. Meem, chief engineer, of Messrs. Cranford & McNamee, the contractors for the adjacent section of subway construction. This consists essentially of a method of supporting the cast-iron shell of the tunnel on foundations built under the tube, and then replacing the lower portion of it by an invert and side walls of reinforced concrete designed to give the required increased depth. A successful trial was made of this method, and it has been adopted for the 400-ft. section near the east end of the south tube, where operations were commenced April 1, and the work is now being executed by those contractors.

The first step is the removal of the two bottom plates in three rings, equal to a length of nearly 6 ft. The first plate is cut through with a chisel and broken out with sledges. The rest of them are barred or jacked out, about one-half of them being broken in the operation. This secures alternate holes about 6 ft. square, around which 2-in tongue and groove vertical sheathing is driven. A 4-in. well point is then sunk in each, and the ground water is removed with a 4-in. Edson pump. This enables the bottom to be excavated to a depth of about 3 ft. A 3-in. layer of 1:3:5 Giant Portland cement concrete is placed in the pit and covered with a large sheet of 1/16-in. lead of considerable greater width than the bottom of the pit, and with the edges rolled.

Concrete is filled in on top of the lead for a thickness of about 18 in., up to the level of the invert, and after it has set a transverse timber bent is placed on it. These bents, 14 ft. apart, support a pair of continuous longitudinal girders made of two 15-in. channels bolted together back to back with a 20-in. I-beam between them. They are in lengths of about 20 ft., breaking joints so that the pieces splice each other. These girders support a second story of transverse bents 4 ft. 8 in. apart on centers. All of the posts are provided with short horizontal top and bottom channels to serve as bearing plates, and the upper ends engage caps fitted to the concave surface of the tunnel plates. The bents and girders are braced transversely by inclined raking pieces, as indicated in the cross-sections, and special care is taken to key the timber very tightly by the abundant use of wedges at all joints.

The weight of the tunnel and its superimposed load having been thus transferred to the concrete piers, the lower plates opposite each hole through the tunnel ring are unbolted and removed up to points near the skewback line. Excavation is made in the ground thus exposed and is carried out a little beyond the edge of the remaining plates, the sides being retained by horizontal lagging boards put in from the top downwards and secured with wooden or iron verticals braced to the concrete footing. Before this excavation is commenced, thin horizontal pieces of wood or steel poling boards are driven under the lower edges of the tunnel plates to retain the sand between them and the lagging. The bottom of the excavation is covered with concrete, and a lead sheet is laid on top of it and soldered to the unrolled edge of the sheet already built into the concrete first laid. The second sheet of lead is continued up the inclined surface of the permanent lagging and is bent over to make a contact with the lower flange of the tunnel plate.

Special half width tunnel plates are inserted between alternate rings so as to provide a continuous lower flange and fill the spaces left by the staggered joints. To the lower flanges of these plates are then bolted webbed cast-iron skewbacks and forms are built up on each side of the tunnel. Steel reinforcement bars 1¼ in. square and 6 in. apart on centers are set up in the position indicated by the diagram, and the concrete is rammed into place, filling the space between the invert and the skewback. Finally grout is forced through holes in the cast-iron plates and the lead sheet between the skewback and the lower segment of the lining is calked, making a watertight joint. After the alternate sections of the tube are thus reconstructed, the continuous girders are supported from the new bottom and carry the weight of the tunnel across the intervening spaces where the original bottom is then removed and the new construction built as already described.

Excavation for Side Wall.

The cast-iron lining of the tubes was originally designed to withstand all stresses developed under normal conditions, but general provision was made in the specifications for reinforcing it whenever it proved desirable. Where the conditions of earth, rock and water pressure were normal, the strength of the rings proved ample and no serious deformation took place. A certain amount of flattening was anticipated on account of the elasticity of the material and proper allowance was made for it in the clearances. This was not exceeded and it is understood that excessive deformation did not occur except as the result of settlement or other extraordinary conditions due solely to the construction methods employed. Where the sand and earth flowed under the tube and allowed the latter to settle, the diminution of pressure on the sides and bottom diminished the external reaction and allowed excessive flattening of the tube which assumed a slightly elliptical form with the major axis horizontal and in some cases left no clearance for the tops of the cars and for the third rail contact. This has not endangered the safety of the structure and will be readily corrected by the methods adopted for the correction of the grade. The maximum variation of the modified grade from the original line is about 1½ ft., and the changes from the theoretical alignment are so gradual that they will be imperceptible to traffic.

It is estimated that all of the changes here described can be completed for about $200,000, which is more than covered by the amounts reserved in the estimates. These corrections are being made under the direction of Mr. George S. Rice, chief engineer, and Mr. Frederick Noble, division engineer for the New York Rapid Transit Railroad Commission. The work is done by Cranford & McNamee for the Rapid Transit Subway Construction Co., of which Mr. George H. Pegram is now chief engineer.

The Long-Distance Conduit of the American Telephone & Telegraph Co., between New York and New Haven, Conn., is the longest continuous conduit system yet laid, embracing over 225,000 trench feet and all classes of construction from vitrified tile to submarine river crossings. All conduit was laid in concrete and in many instances iron pipe was used, while in trenches excavated through rock, wooden duct was installed to withstand possible future blasting nearby. Nearly 500 manholes were built, the average distances between them being 400 ft.

The Utilization of Water Powers of Low Head.

The electric light company in Janesville, Wis., a city of about 15,000 inhabitants, has improved its condition by getting away from an old-time uneconomical plant to one of modern construction which is capable of producing current with so much economy that the business has extended enormously during the last three years. The company has been able to utilize three separate water powers, two of which are used for continuous service, and the third for peak-load service. An interesting account of the improvements was read before the recent convention of the American Institute of Electrical Engineers, from which the following notes have been prepared.

Three or four years ago the Janesville Electric Co. was operating a power house in the heart of the city, and was there utilizing a small amount of water power in conjunction with a considerable amount of steam power, the latter generated under conditions of much inconvenience and lack of economy. The company also owned a small water power some miles from the city, and it utilized this for operating a synchronous motor in the city station. The company came into hands with financial strength and keen foresight, and it obtained nearly exclusive water rights at two dams on the Rock River, within the limits of the city.

At a point a few blocks from the business center, there is a timber dam long used to develop power originally utilized for running a grist mill and other purposes, a canal of some length having been extended along the margin of the river through a portion of the city. The company obtained rights for the greater portion of the power on this site, and also the site of the old mill on which the company has erected a fireproof power house.

Just before leaving the limits of the city the river is crossed by another timber dam which formerly supplied power to a woolen mill, and of recent years also furnished the power for operating a cotton mill; but the latter was closed, and the company was enabled to obtain its site with power plant and the greater portion of the water rights at this dam.

The third water power is a small one about 12 miles from Janesville, the water rights of which are owned exclusively by the company.

The plants at these three power sites are known respectively as the Central, Monterey and Fulton stations.

On securing the water rights and mill site where the Central plant now stands, the company placed the development of a suitable electrical generating plant in the hands of engineers. The old mill was torn down, a suitable forebay excavated, reinforced concrete penstocks erected, suitable waterwheels installed, and measuring gates erected at the entrance to the forebay. The measuring gates are large movable gates which are required because the company does not own quite all of the water rights. They were installed under the direction of the county court for the purpose of properly dividing the water between the owners in accordance with their proportionate ownership. The concrete work for the penstocks was prosecuted in midwinter with the temperature at times 12° to 16° below zero, but careful precautions were taken and the concrete has proved exceptionally free from defects.

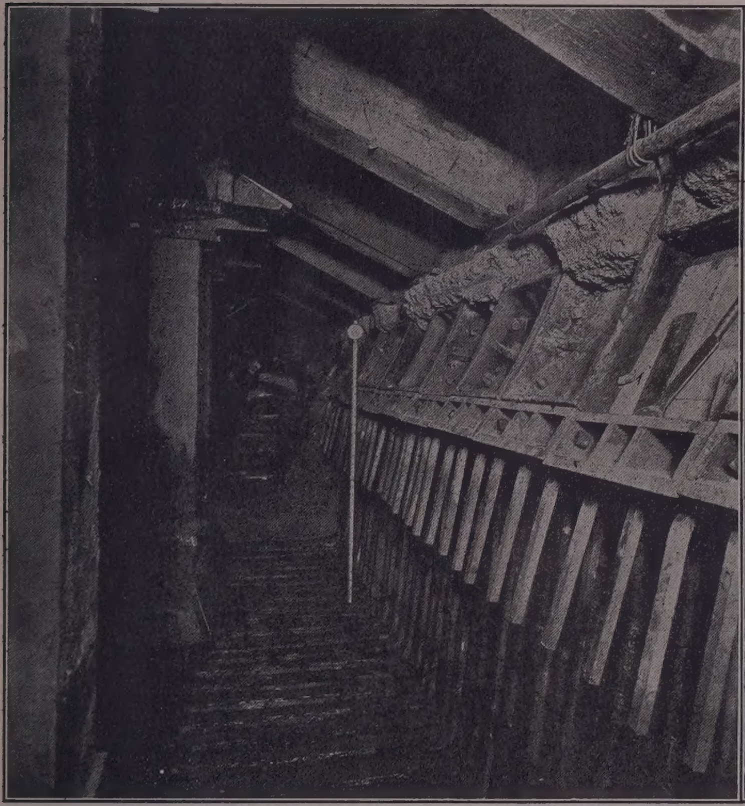
The dam at the Central plant affords a head of 8. ft. at normal water, which is somewhat reduced in the case of high flood waters on account of the effect of back water. The Rock River rises in a marshy region in central Wisconsin, and has a drainage area of approximately 3,250 square miles. It is a river of reasonably equable flow, though it is subject to quite low water in the late summer and rather high water in the early spring. Ordinarily it has a very satisfactory flow during those months that afford the greatest daily load for the electric light company.

The equipment installed at this point consists of four wheels rated at 148 h.-p. each, and two rated at 100 h.-p. each, the four being arranged to drive a main horizontal shaft, while the two drive an independent shaft. The latter two are wheels which were owned by the company when this plant was developed, and they were temporarily installed for use until the demand for power shall become sufficiently great to make it worth while to replace them by wheels corresponding to the other four.

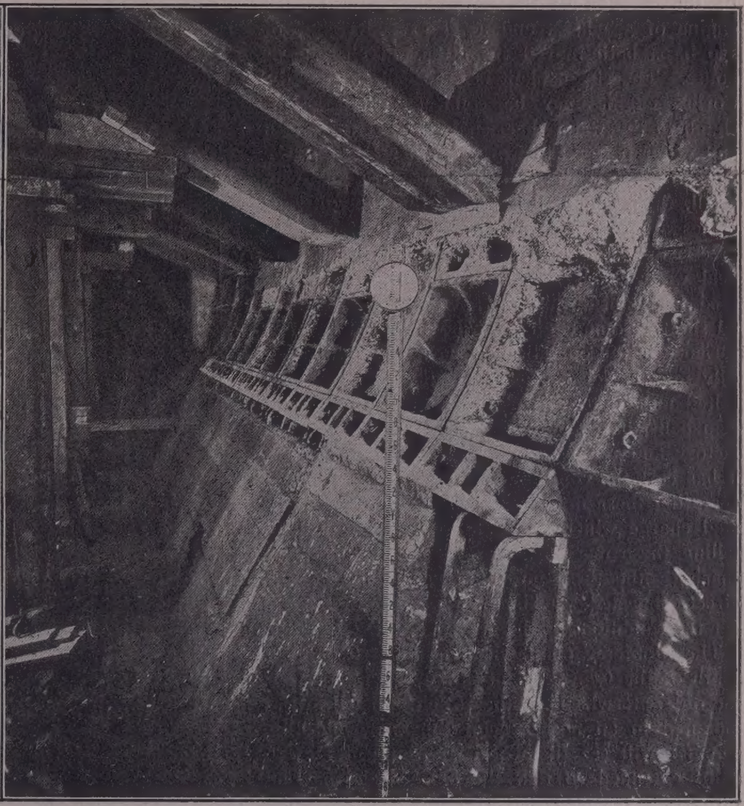
The company had been operating a rather mixed lot of circuits including Edison direct-current three-wire system, 110 volts on a side, for incandescent lamp lighting, with 220-volt, direct-current motors between the outside wires; 500-volt railway circuits; alternating-current incandescent electric lighting circuits; direct-current series arc lighting circuits, and circuits to polyphase alternating-current motors. This mixed system had partially come about through the merging of two companies a considerable number of years ago, and partially through the gradual development of the plant toward an alternating-current plant.

When the Central plant was constructed and the old plant in the heart of the city abandoned, it was decided that the better economy lay in preserving the mixed system for the present, since considerable of the machinery was in very good shape and a good many direct-current motors were in use. Consequently the company still maintains the direct-current three-wire system, the 500-volt electric railway circuits, and its alternating-current circuits for incandescent lighting and motors. It has changed its arc light system so as to use alternating-current series arc lamps operating from Thomson tub transformers.

A synchronous three-phase alternator of 6,600 volts pressure had been in use as a motor driving a jack-shaft in the old city station, receiving power from the Fulton plant, for the purpose of aiding the old city station in coping with its peak-loads. This machine of 85 kw. capacity, and another three-phase alternator of 150 kw. capacity were installed in the Central plant,



Skewbacks and Reinforcement Placed for Side Walls.



New Invert and Side Walls of Battery Tunnel Completed.

and these are connected to the switchboard in such a manner that they may be used as synchronous motors to receive power from either or both of the other generating plants, thus aiding to drive the generators in the central plant. Likewise, they may be used as generators, being driven by the shaft of the Central plant, and thus deliver power to the polyphase alternating-current circuits and tub transformers.

The Central station stands on made ground between the old power canal and the river bank. The foundations are supported on piles. When it came to building the house it was found that a concrete block building could be put up more economically under the particular circumstances than a building of brick and the block construction was therefore chosen. Rock-faced blocks were used in the exterior lower courses and the pilasters of the building, while blocks with imitation bush-hammered faces were used for the remainder of the exterior. The roof-trusses are of steel, and the roof is covered with fireproof roofing. A corrugated-iron extension serves as a covering for the wheel settings.

The equipment in use in the power house includes a water-tube boiler purchased at the time of the erection of the power house, a Corliss engine of 300 h.-p., and a high-speed engine of 150 h.-p., both moved from the old city power house. The steam plant is arranged so that the Corliss engine may be connected by friction-clutch to the waterwheel shaft so that the steam and water power can work together.

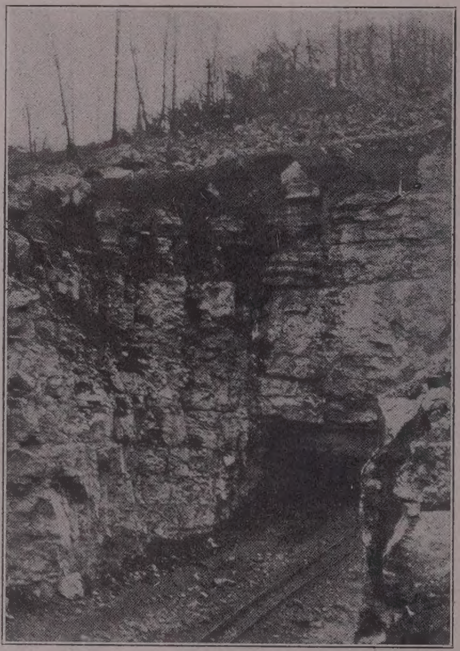
As the generators in this station are relatively small, they are all belted, and the 110-volt machines are operated in pairs by tandem belts to save space. The low head makes the use of vertical waterwheels necessary, and bevel-gears are used for transmitting the power to the horizontal shaft. Some engineers who have not had experience in the operation of such plants undoubtedly may criticize the introduction of the small belted units into this plant and the use of tandem belts, but experience shows that it is satisfactory and reliable; and there is no doubt that it has cost the company less per annum through operating these machines than the additional annual charge which would have been imposed by selling these machines at second hand and purchasing others of uniform type. The use of direct-connected machines is not practicable under the conditions of the plant.

The Monterey plant which is about two miles south of the Central plant is now operated from the old waterwheels of the cotton mill which are mounted in an unsatisfactory manner, and this summer will see the wheel development at this point extended so that the old wheels may be ultimately replaced and the full power of the site taken advantage of. There is also located at this point an admirable Corliss engine of 350 h.-p., which was part of the cotton mill equipment and is maintained by the electric company as part of its steam reserve. One 275-kw., three-phase generator is now temporarily installed in this plant, driven by the old wheels of the cotton mill, of which there are four, three being rated at 100 h.-p. each, and one being rated at 50 h.-p. Additional generating capacity will be added this summer after new concrete penstocks have been put in, and two new waterwheels of 250 h.-p. each have been installed therein. The old equipment will probably be maintained for another year to operate in conjunction with the new, after which it will be replaced by larger and better apparatus.

The generating capacity of this plant may be utilized in cooperation with the Central plant, either by operating a synchronous motor at the Central plant to aid in driving the direct-current machinery, or by delivering the alternating current to the alternating-current distributing system through the Central plant switchboard or both.

The head which the Monterey dam affords at normal water is approximately 9.5 ft., which is somewhat reduced at times of excessively high water. A fair amount of storage exists in the pond above the dam at each of these plants, namely, the Central and Monterey plants, so that advantageous use may be made of the water for the variable load of the lighting company.

The Fulton plant is about 12 miles northerly from Janesville. It is located on the Yahara River, which is the outlet of a string of lakes having a surface area of about 60 square miles. The total drainage area covers approximately 510 square miles above Fulton. The head afforded by the dam is 14 ft. and the pond above the dam affords considerable storage capacity. This plant is therefore used only for peak-loads and is consequently operated only a few hours each day, under ordinary conditions. The plant has been in its present condition for a number of years. Its equipment includes three 75-h.-p. waterwheels and a 150-kw., three-phase generator. The waterwheels are vertical wheels geared to a horizontal shaft. A small generator is also installed in this power house for the purpose of contributing to the lighting of the town of Edgerton. The latter generator is supplied by the owner of the electrical supply, who owns a water power site of very low head on the Rock River and found it desirable to buy some of his power from the Fulton plant.



West Portal, Lookout Mt. Tunnel.

This Fulton plant has a transmission line of 6,800 volts pressure. The city distribution circuits on the alternating-current system are of 3,200 volts pressure. The alternating-current machines in the Monterey and Central plants are of 2,200 volts pressure with the exception of one old synchronous machine which is of 6,600 volts pressure. Transformers suitably located with respect to this 6,600-volt machine in the Central plant make it possible to use it in connection with the 2,200-volt lines as motor or generator, or to receive power from the 6,600-volt line from Fulton. The same transformers also provide means by which the 6,600-volt line may feed directly into the 2,200-volt distribution circuits.

Under usual conditions of operating, the two alternating-current machines in the Central plant are utilized as motors in driving the direct-current machines, deriving their power from the other two stations, and the alternating-current distribution lines of the system are supplied by current from the other two plants through the Central plant switchboard. The arrangement of the switchboard affords the possibility of operating the plants in any combination on the distribution circuits, either with each other or singly, as the storage of water or other conditions may make desirable.

The drainage area of the Rock River above Janesville includes nearly the whole of the counties of Dane, Jefferson and Dodge, and considerable portions of the counties of Rock, Waukesha, Washington and Fond du Lac, most of which are notably excellent and well cultivated farm and dairy counties. This gives a reasonable basis for expecting fairly stable conditions of the water power, so that the future power may be reasonably estimated from the records of the past.

A peculiarity of the under soil of the area robs the river at Janesville of that uniformity of flow throughout the months of each year which might be expected from the considerable area of lakes and marshes which contribute to the waters of the river. A substratum of sand and gravel or sandy nature lies beneath the surface soil and carries a heavy flow of underground water throughout the year. It may be reasonably supposed that a goodly proportion of the total waters discharged from the area are found in this underground flow and that the apparent river flow suffers most of the fluctuations following precipitation, thus causing an increased ratio between the waters discharged by the river in the high and low-water months of each year.

The Lookout Mountain Tunnel, Southern Railway.

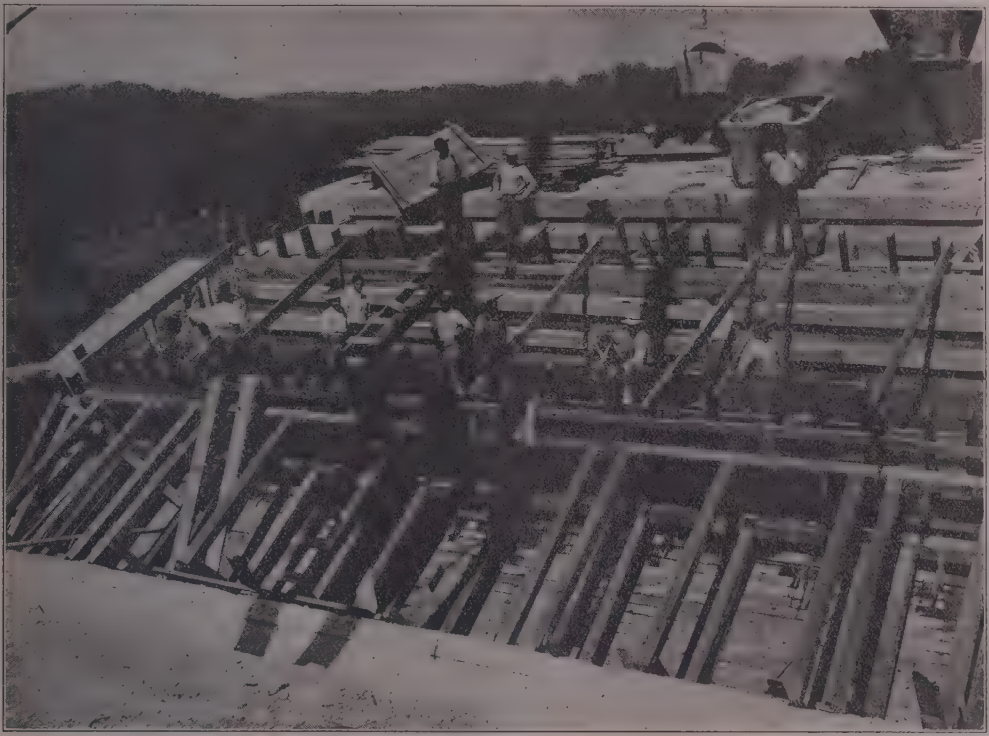
One of the most interesting excursions made during the recent convention of the American Society of Mechanical Engineers was to the tunnel which is being driven under Lookout Mountain to carry two tracks of the Southern Ry. It is the first double-track tunnel in the South and the first example there of work being done with a bottom heading driven first, instead of the customary top heading. After the heading is complete the top will be drilled and blasted down, and the mucking will be done by a Marion steam shovel operated by compressed air. The tunnel parallels at a distance of 125 ft. and on a higher level the single-track line of the Nashville, Chattanooga & St. Louis Ry., which skirts the base of the mountain on a surface location. The tunnel is 3,540 ft. long, 28 ft. wide on tangents, 34½ ft. high from the base of rail to crown and is being driven with a bottom heading 9 ft. high. The West approach is 350 ft. long and the East approach 300 ft.

The power plant is 800 ft. from the west portal and comprises two class A 20x22¼x24-in. Ingersoll-Sergeant air compressors, twelve 3¼-in. Ingersoll-Sergeant rock drills, an Ajax drill sharpener, a 500-light Bullock dynamo, a Cameron pump operated with compressed air and equipped with an Ingersoll reheater, a 16,000-gal. water tank, a 100-h.-p. horizontal tubular boiler and two 80-h.-p. internally-fired boilers. The main air line from this plant is 6 in. in diameter and ends at the portal, where a 4-in. branch is taken into the heading and another 4-in. branch is taken over the mountain to the East portal.

The work on the west heading was begun Nov. 1, 1905, and has progressed at the following rates: November, 250 ft.; December, 200 ft.; January, 290 ft.; February, 296 ft.; March, 218 ft.; April, 214 ft. The rock penetrated is the Chickamauga limestone, and its appearance and character are indicated in the accompanying illustration of one of the portals. During the month of March there was also driven an air course at right angles to the tunnel axis and 876 ft. from the portal; this was 8x10 ft. in cross-section and 87 ft. long and opens through the bluff above the Nashville, Chattanooga & St. Louis track. On account of the continuous train service on this track very light blasts were necessary when driving the air course near its open end, and a center cut was made with an Ingersoll-Sergeant radialaxe machine.

A round of holes numbers from 30 to 33, which are 12 to 14 ft. deep, and 350 lb. of 60 per cent. Forcite are used in blasting. One round is drilled, blasted and mucked out every 24 hours. All the drill steel is sharpened by an Ajax machine operated by compressed air.

At the East portal progress has been more slow on account of the very treacherous formation encountered, the line passing through loose ground and boulders. Small drifts were driven on each side for the wall plates, extending back about 100 ft., and the timber lining was then carried on back to the East portal and at the same time carried ahead. The timber used was 12x12-in. oak, nine pieces to each arch, lagged with 4-in. oak. The timbering required was 1,000 ft. B. M. to each running foot of tunnel, and the excavation was so treacherous that only sufficient work could be done ahead to admit of one set of timbers at a time. In taking out the bottom it frequently requires three sets of temporary legs under the wall plates before reaching grade. Inside of this timber work there will be a 3-ft. concrete arch completing the tunnel, which is being driven 34 ft. wide at this end. Mr. Wm. J. Oliver, of Knoxville, has the contract for building the entire line to the State boundary, and Messrs. H. H. Thrasher & Co., of Knoxville, are driving the tunnel.



Depositing Concrete in Section of Arch Ring.

THE COAL BRIQUETTE MAKERS of Germany have formed a cartel or trade association for the purpose of guarding against over-production, although Consul Hurst at Plauen believes that a strengthening of prices is also proposed. In a general way it seems that the methods of the Rhenish-Westphalian coal cartel will be followed. Uniform prices with only a slight discount for large orders will be established.

Arch Construction of the Connecticut Ave. Bridge, Washington.

Connecticut Ave., Washington, crosses Rock Creek at the height of about 120 ft. above the water on a bridge 1,341 ft. long and 52 ft. wide which includes 7 full center arches of 82 ft. and 150 ft. clear span. The arches are all hingeless, are made integral with the upper parts of the piers and are built without steel reinforcement. Horizontal footings are offset on their upper surfaces for the piers of 14 ft. spandrel arches which carry the roadway platform. The arches are of concrete cast in place except for the ring stones which were moulded in forms at the site and were set like cut stone masonry. The general features of design, the main falsework, and the construction of the piers and abutments were described in The Engineering Record of July 8, 1905.

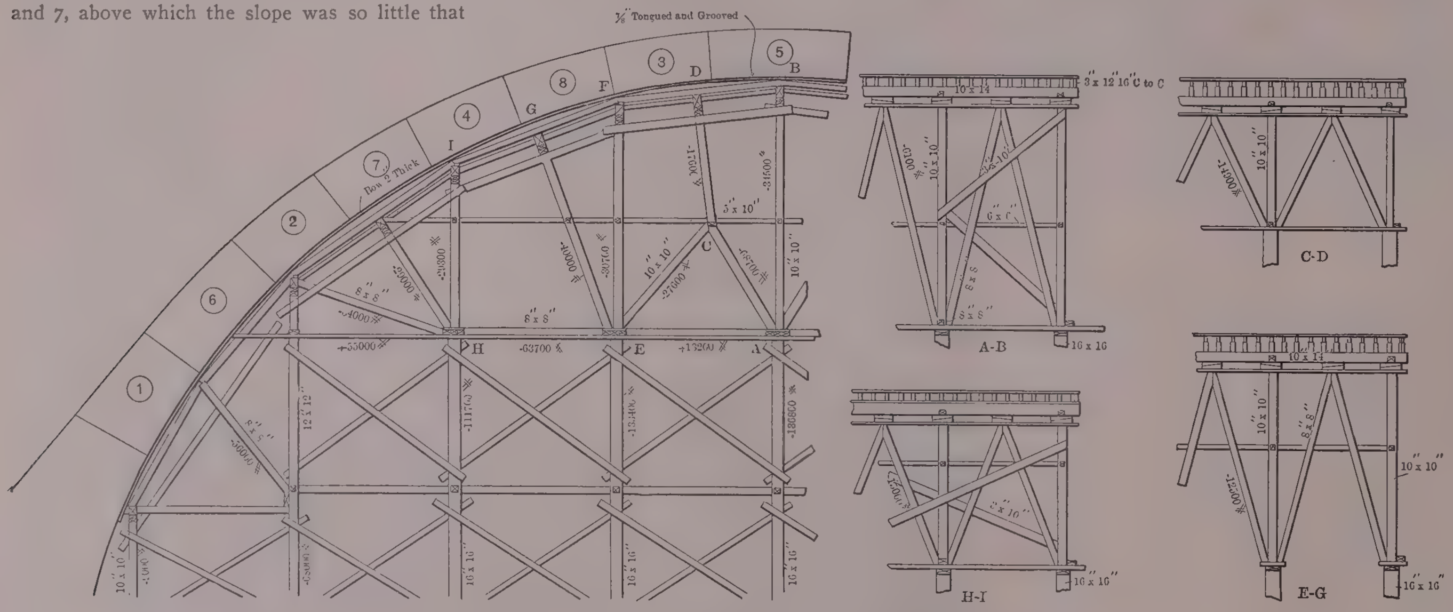
Building Alternate Sections and Courses of Arch Ring.

During the summer and fall of 1905 the arch spans were built on falsework substantially as illustrated in our previous article, but modified in some respects as indicated by the accompanying partial elevation and sections. The arrangement of the bracing in the upper panels was changed, generally in the direction of simplifying it. Considerable pains was taken to proportion the timber in accordance with the maximum dead load stresses and resulted in the varying sections here shown. The X-braces in the main bents are all single 3x8-in. planks. The inclined posts which support the longitudinal caps at their center points are all 8x8-in. except in the two panels nearest the center where they are 10x10-in. The horizontal struts are 8x8-in. and the longitudinal caps are uniformly 3x12-in. The main posts are capped transversely with 10x14-in. timbers seated at every post on pairs of 10x24-in. oak wedges which are also placed at intermediate points. They all take bearing on 3x10-in. planks parallel to the caps which are secured to the tops of the vertical posts and are supported intermediately by pairs of 8x8-in. inclined posts reducing their span and transferring the loads to the main vertical posts which are increased in size at this level. The horizontal, longitudinal and transverse struts are in most cases 6x6-in. or 8x8-in. pieces except at the points where the vertical posts change their dimensions where the transverse struts consist of three 5x10-in. pieces.

The numbers in the face of the arch shown on the falsework elevation indicate the sequence in which the ring blocks were laid in erection. In all cases they were set symmetrically on opposite sides of the center, and built up simultaneously from both skewbacks so as always to impose balanced loads on the falsework. In order to avoid danger of cracking the blocks, lead joints were made between the adjacent ring blocks and at every joint of the large concrete sections back of them. Each of these sections included five face blocks, and had a length of about 10 ft. From the springing line to block No. 1, the concrete was made continuously and is monolithic with the pier and with the adjacent arch. Above that point it was cast in transverse strips or blocks which, as before stated, had a length of about 10 ft. measured on the intrados of the arch, transverse to its axis, and corresponded to the length of five adjacent ring blocks.

Each transverse section was divided into five parts by four intermediate longitudinal partitions, as indicated in the photograph. In sections Nos. 6 and 7, which as will be seen by the falsework diagram, were cast after the adjacent sections, the intermediate portions marked B and D in the photograph were cast first in order to support the section above and prevent it from sliding down on the steep slope of the lagging. After this was done the struts which are seen in the middle of the adjacent pockets in the mould were removed and the remaining three portions of the section marked A, C, and E, at the sides and ends of the section were cast. The other sections of the arch were all cast full width at first. The upper part of the concrete in the arch ring was enclosed by form boards which were placed over it at the lower edge of each section and were built on upwards as the concreting progressed. These forms were required only for sections 1, 6, 2 and 7, above which the slope was so little that the concrete was finished with a trowel and top forms were not necessary to retain it. When section No. 7 was concreted section No. 8 was temporarily loaded with concrete blocks in order to secure as nearly as possible the final settlement of the falsework.

Temporary Loading at Crown During Erection of Arch.



Falsework for Connecticut Avenue Bridge, Washington, D. C.

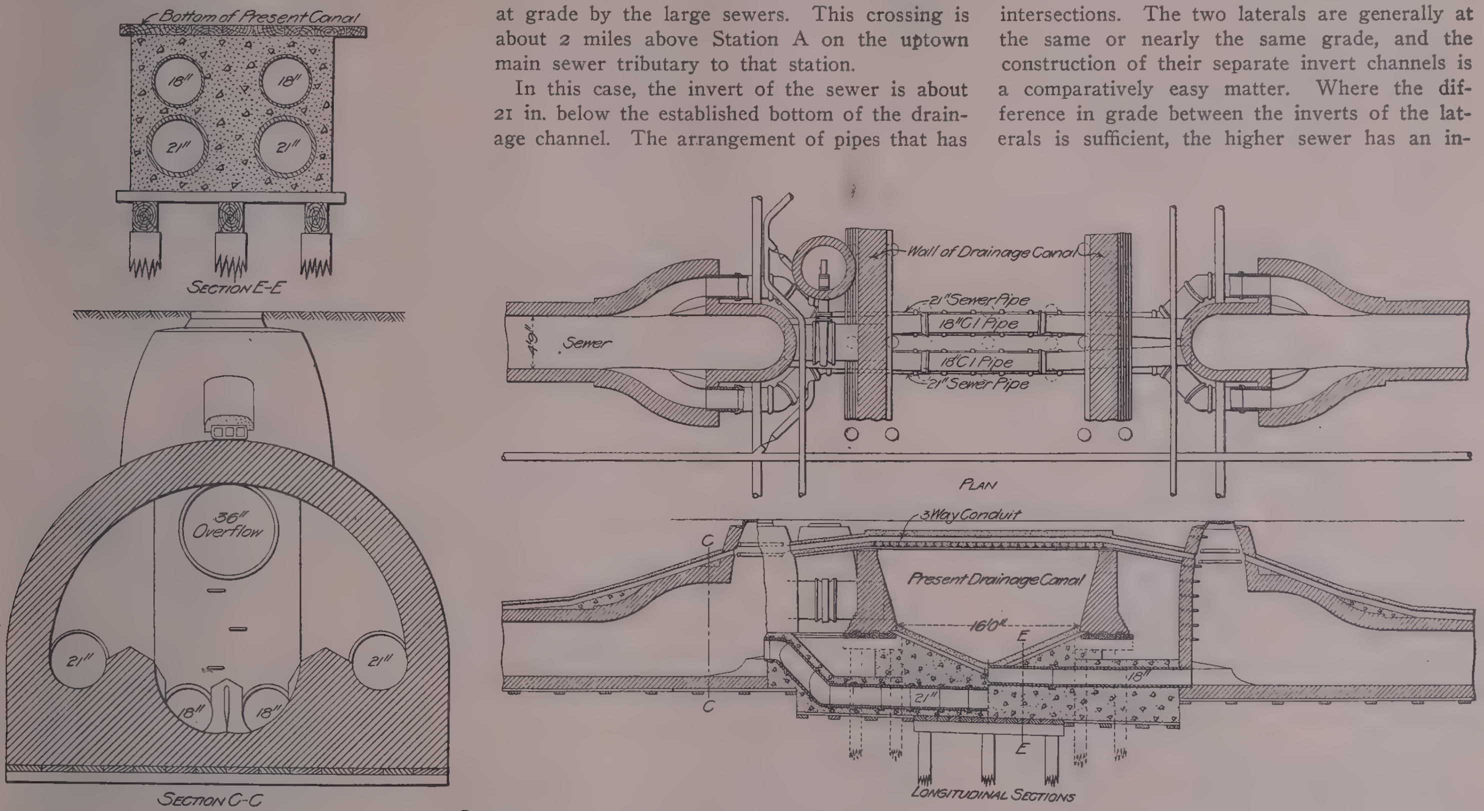
The concrete was mixed at one end of the bridge and was delivered to the different arches as required in steel buckets carried on cars on a surface track parallel to the bridge and about 30 ft. above the springing line. This track was inclined about 2 per cent. down from the mixer so that the full cars were easily delivered by gravity and the empty ones could be pushed back by hand. The buckets were handled from the cars by guyed derricks set on every pier. Five arches were built simultaneously and work on them was maintained at about the same relative position in all cases. No difficulty was experienced in forming the keys which was done in casting the two sections, No. 8, one on each side of the center line which closed the arch ring. This sequence of construction was adopted in order to eliminate from the falsework practically all of the deformation at the center which it would develop under full load. This result was satisfactorily obtained and no trouble was had with settlement. The maximum settlement was 3½ in. at the crown and the average settlement was 2½ in. The maximum settlement of the pile foundations was ½ in. and the average was ¼ in. Where the bridge crossed the bed of the creek the falsework was supported on concrete piers with their footings carried down to hardpan, and showed no settlement.

The total quantity of concrete in the arches is 8,884 cu. yds., and was laid at the rate of 184½ cu. yds. per day. The concreting of section one of the arches was commenced August 18, section 2 was not commenced until September 13, which was regarded as practically the time for the actual commencement of the arch construction. The arches were completed November 6, making the actual time 48 days. The arches were built by the District Construction Company, under the supervision of Col. John Biddle, engineer commissioner, D. C., Captain J. J. Morrow, assistant to the engineer of commission, Mr. W. J. Douglas, engineer of bridges, D. C., and Mr. F. A. Perley, assistant engineer.

Specially Designed Condensers of both surface and jet types have been furnished for Curtis turbines by Messrs. W. H. Allen, Son & Co., Bedford, England. In all cases the condenser shell forms the base on which the turbine is carried, and the step bearing for the main shaft is a part of the shell. In the surface type there are two sets of ¾-in. brass tubes for the circulating water, and these tubes are supported at several points by plates which also act as baffles, causing a thorough distribution of the steam. Provision is made for flooding the condenser to prevent excessive heating when the turbine is run non-condensing. In a jet condenser recently furnished to the Leeds street railway power station, the injection water is admitted to four rings of bronze pipe, one above the other, each fitted with a number of atomizing nozzles. The water issues from these nozzles in a fine spray. The rings have regulating valves, illustrated in "Engineering," by which the amount of injection water can be nicely adjusted.

The Sewerage System of New Orleans.—II.

The general plan of the sewerage system was shown in one of the illustrations printed with the first part of this article. The legend on that map shows the general arrangement of the system and the present status of the work. The principal part of the city is tributary to a large central high-lift pumping station, called Station A, near the lower end of the bend of the river on which the city is built. A force main extends from this station to the river. Two main sewers are tributary to the station, one extending down the river for 1½ miles and the other extending up the river along the rear of the principal part of the city for about 5 miles. Branching from these main sewers are sub-mains which extend toward the river and back inland from them. The mains and sub-main sewers only are shown on the map. Toward the lower end of the city is a second high-lift pumping station, Station B, discharging into the river. This station will serve the portion of the city not served by Station A. On the opposite side of the river is the third high-lift pumping station, Station C, which serves all the portion of the city on that side of the river.



Crossing of Main Sewer under Drainage Canal.

The main sewer tributary to Station A, which extends up the river along the rear of the principal part of the city, is the largest sewer in the system. It has a 7-ft. circular section in the first 150 ft. from the station, in order to allow for future sewers. Beyond this 7-ft. section a 5-ft. 4-in. by 6-ft. 8-in. oval section, built of brick, extends for 4,000 ft. This oval sewer was nearly all built by the old sewerage company. A concrete sewer with a 5.75-ft. circular section begins at the upper end of this oval sewer. This concrete sewer is continued, gradually reducing in size to 3 ft. 3 in. diameter, for which size a circular brick sewer is used. The portion of the main 3 ft. in diameter or less is built of vitrified pipe.

The smallest sewers in the system are 8 in. in diameter and constitute 87 per cent. of the total mileage. Sewers up to and including 24 in. in diameter have been built of vitrified clay pipe; between 24 and 36 in. in diameter, they have been built of pipe or brick, and above 36 in. of brick or plain concrete. The large sewers are, of course, not expected to receive for some time the full amount of sewage for which they are designed. The ground water which unavoidably enters the system will, however, produce a good initial flow in them, insuring not only a proper velocity, but also a fairly uniform volume. For that reason, the sewers have, with few exceptions, been made circular in cross-section.

A number of interesting features have been included in the design and construction of the mains and sub-mains of the system. A large number of conflicts with the grades of drainage channels could not be avoided, without involving greatly increased and unwarranted cost of construction. The sewers cross under these channels in siphons, the greater part of which occur on the pipe sewers near the head of the system. Owing to the greater depth of the main sewers only one drainage channel is intercepted at grade by the large sewers. This crossing is about 2 miles above Station A on the uptown main sewer tributary to that station.

In this case, the invert of the sewer is about 21 in. below the established bottom of the drainage channel. The arrangement of pipes that has been installed at this crossing to carry the flow in the main sewer under the drainage channel is shown in one of the accompanying illustrations. Two 18-in. cast-iron pipes are laid side by side under the drainage channel and on the grade and line of the sewer. These pipes have sufficient capacity to carry the minimum flow of the sewer, and their inverts are at the same elevation as the invert of the latter. When the amount of flow increases until they are overcharged the excess is carried by one or both of two 21-in. cast-iron pipes laid as siphons immediately under the 18-in. pipes. The 18-in. pipes are self-cleansing; suitable connections with the water-works mains are provided for flushing the 21-in. pipes. A 36-in. overflow connection leading to the drainage channel is provided and is fitted with a valve, so that in an emergency the flow can be diverted to that channel. Overflows from the main sewers into other drainage channels are also built at various places, to provide for unexpected volumes of flow or accidents to the mains or pumping stations. The siphons on the pipe sewers do not involve any unusual features. Two lines of pipe are generally laid in concrete under the drainage channel that is crossed and each line provided at its upstream end with an automatic flush-tank.

All junctions of the sub-mains and laterals with the main sewers are made in drop manholes, the bore being continued at grade through the side of these manholes. A pipe length back from the latter, a T-connection is placed in the sub-main or lateral and the stem of the T extended down to or below the springing line of the arch of the sewer, where a connection is made with the barrel of the main sewer. A small dam is placed in the bore of the lateral or sub-main extending through the side of the manhole and the flow diverted into the main through the drop connection.

The manner in which the lateral sewers are laid alternately parallel with and at right angles to the same straight line brings two laterals together at the corners of many blocks and permits one manhole to serve the two laterals at each of these corners. In order to maintain an independent flow in both of the laterals, special manholes with depressed invert channels are built at such intersections. The two laterals are generally at the same or nearly the same grade, and the construction of their separate invert channels is a comparatively easy matter. Where the difference in grade between the inverts of the laterals is sufficient, the higher sewer has an invert built in a bench along one side of the manhole and over the lower sewer.

Flushing is provided by an automatic flush tank at the upper end of each lateral; the automatic apparatus in these tanks was furnished by the Pacific Flush Tank Co., of Chicago, about 800 tanks being required in the portion of the system that has been built. The air dome of the flushing apparatus in each tank is placed at one side of the sewer connection so that a clear line of sight is presented in the latter between the flush-tank and the first manhole. Owing to the upper ends of many of the laterals being only 5 ft. below the surface a large number of shallow tanks had to be built.

A 30-in. connection is made about 1¼ miles above Station A, between the main sewer and a large navigation canal, leading to Lake Pontchartrain, under which the main sewer is built. This connection is provided with a gate valve, and as the water in the canal has a head of 15 ft. over the invert of the sewer, sufficient water is available for flushing this portion of the mains.

The force main leading from pumping Station

A to the river is the largest force main in the system. It is 7,200 ft. long and consists entirely of cast-iron pipe with lead joints. The first 2,800 ft. from the station consists of a double line of 36-in. pipe, and the remaining 4,400 ft. is a single line of 48-in. pipe, which extends through the levee along the river. On the river side of the levee, the 48-in. pipe terminates in a T-connection, with two 36-in. flexible joint pipes. This T-connection is on a heavy timber cribbing built under a wharf along the river. The two 36-in. pipes extend vertically down to the river bed from the connection and then on a slope 50 ft. out into the stream, where their ends are 40 ft. below low water.

The pumps in Station A will be driven by steam engines. The pumps in Station C, on the opposite side of the river, will also be driven by steam. Pumps in all of the remainder of the stations will be direct-connected to electric motors, which will be supplied with power generated in Station A. As this station is the central power station for all of the remaining stations, except Station C, and as a large part of the total sewage flow will be handled through it, it is in a much larger building than any of the other stations. The building is a one-story brick structure, 38 ft. high to the line of eaves, and has a roof of ornamental red tile, made by the Ludowici Roofing Tile Co., of Chicago. It consists of a 50x170-ft. engine room at the front, with a 46x76-ft. boiler room and a 10x28.5-ft. screen chamber on the rear side of this engine room. The building stands on a concrete footing built on piles.

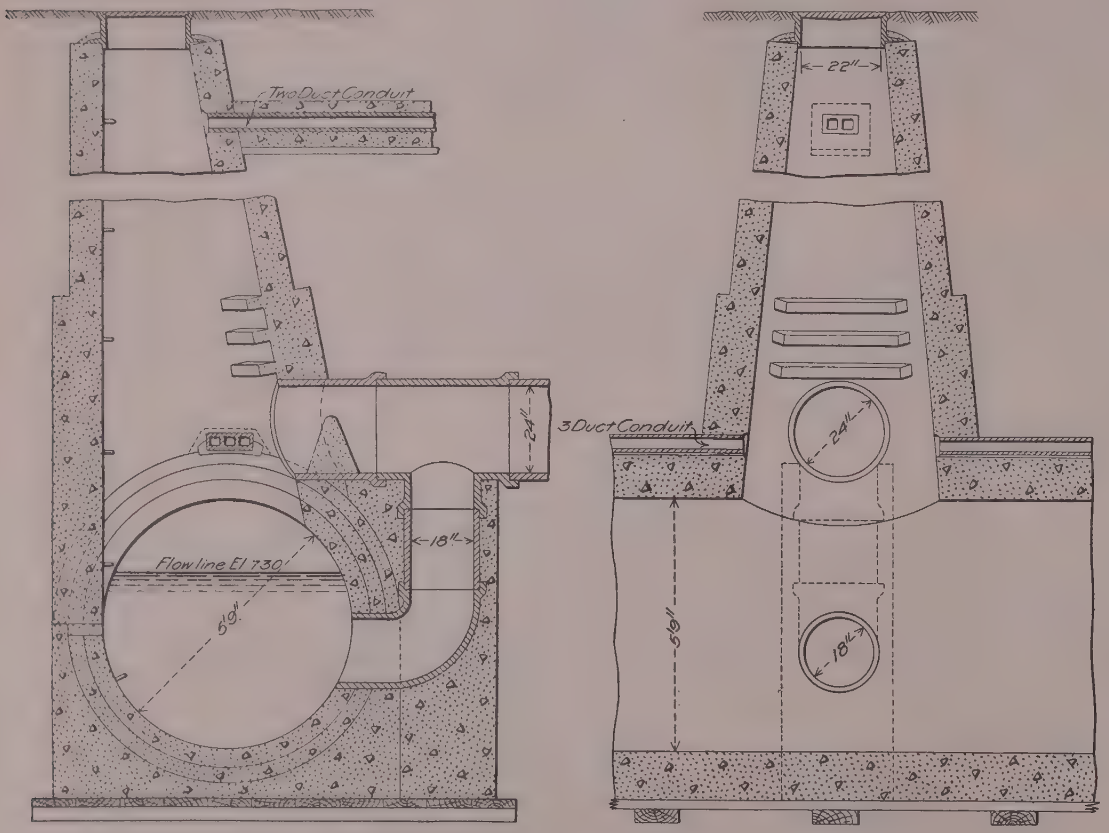
The ultimate pumping equipment will consist of three horizontal centrifugal pumps. Two of these are now being installed and have a capacity of 3,500 cu. ft. per minute each under the maximum operating conditions. The third pump will be installed later and will have a larger capacity. The estimated present discharge from the territory tributary to this station is 26,000 gal. a minute, with an estimated ultimate future discharge of 57,000 gal. a minute, or 82,000,000 gal. per 24 hours. These pumps are placed in concrete pits below the floor level of the building. The accompanying cross-section and longitudinal sections of the station building show the arrangement of these pits, in which two of the pumps are being installed. The pits are in a row along the rear side of the engine room. Each pit is 24.25 ft. in diameter and 22 ft. deep. The central pit is on a line with the screen chamber at the rear of the building. The screen chamber is at the end of a 7-ft. main sewer which conveys the flow from the up and down town main sewers along the rear of the city to the station. The 7-ft. sewer is connected through this screen chamber to channels leading to each pump pit.

Each pump will be driven by a C. & G. Cooper triple-expansion condensing engine, mounted on an engine bed around the top of the pump pit. The total head against which the pumps will operate will vary from 30 to 56 ft., depending on the stage of water in the river. The bottom of the screen chamber at the end of the main sewer is 6.5 ft. below the bottom of the pump pits, but the suction lift required of the pumps will never exceed 9.6 ft. The pumps discharge into the 36-in. cast-iron force mains leading to the river. The maximum actual lift caused by high water in the river is 42 ft., with an additional friction loss of 14 ft. These engines and pumps are designed to produce their maximum efficiency and rated discharge when working at 165 lb. steam pressure at the throttle, and at 100 r.p.m., against a 35-ft. head. They are also designed to be capable of a sufficient increase of speed at the same steam pressure to maintain their rated discharge against a 56-ft. total head. Steam to operate the pumping engines is supplied by a battery of four 250-h.-p. Heine water-tube boilers in the boiler room. These boilers are served by a 150-ft. radial brick stack of 6 ft. internal diameter, built by the Alphons Custodis Chimney Construction Co.

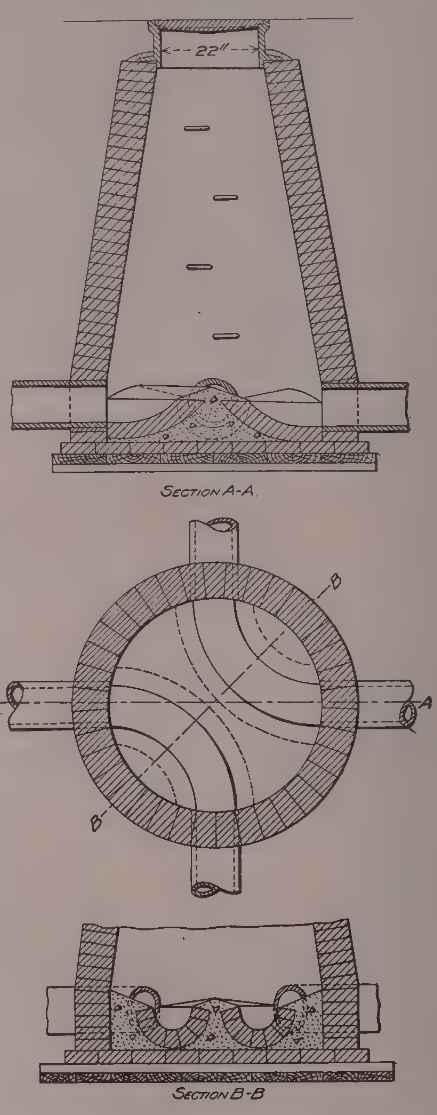
Two 3,300-volt, 25-cycle, three-phase alternating-current Westinghouse generators, each direct connected to a C. & G. Cooper 350-h.-p. compound condensing engine operating at 110 r.p.m., are also installed in the engine room of Station A. Each of these units has sufficient capacity to supply power to operate the pumps in four of the first lift stations, the pumps that will be installed at once in the two intermediate low-lift stations built on the line of the main sewers as well as the present pumping equipment of Station B. Settings are provided in Station A for other generators as the pumping equipment of the other stations is augmented and the stations still unbuilt are erected and equipped. Power is transmitted to the various stations through cables in vitrified clay conduits laid in concrete on the extrados of the main sewer arches, or in the trenches of the smaller sewers. The possibility of the service being crippled by damage to the transmission lines is thus greatly reduced. The transmission lines for the principal stations are nearly all in conduits built on the main sewers so that an excellent foundation is provided. The manholes of the sewers serve as pulling manholes for the cables.

The required estimated present capacity of Station B is 2,500 gal. a minute. Owing to a considerable portion of the territory served by this station being but sparsely built up the ultimate capacity of the station is expected to reach 13,000 gal. a minute. Its present equipment consists of two horizontal centrifugal pumps, each with a capacity of 670 cu. ft. per second against a total head varying from 23.5 to 44.5 ft. The general arrangement of the pumps in pits at this station is similar to the arrangement of Station A. Each pump is direct-connected by a vertical shaft to a 100-h.-p. Westinghouse induction motor mounted on the floor over the pump pit.

The design and arrangement of the intermedi-

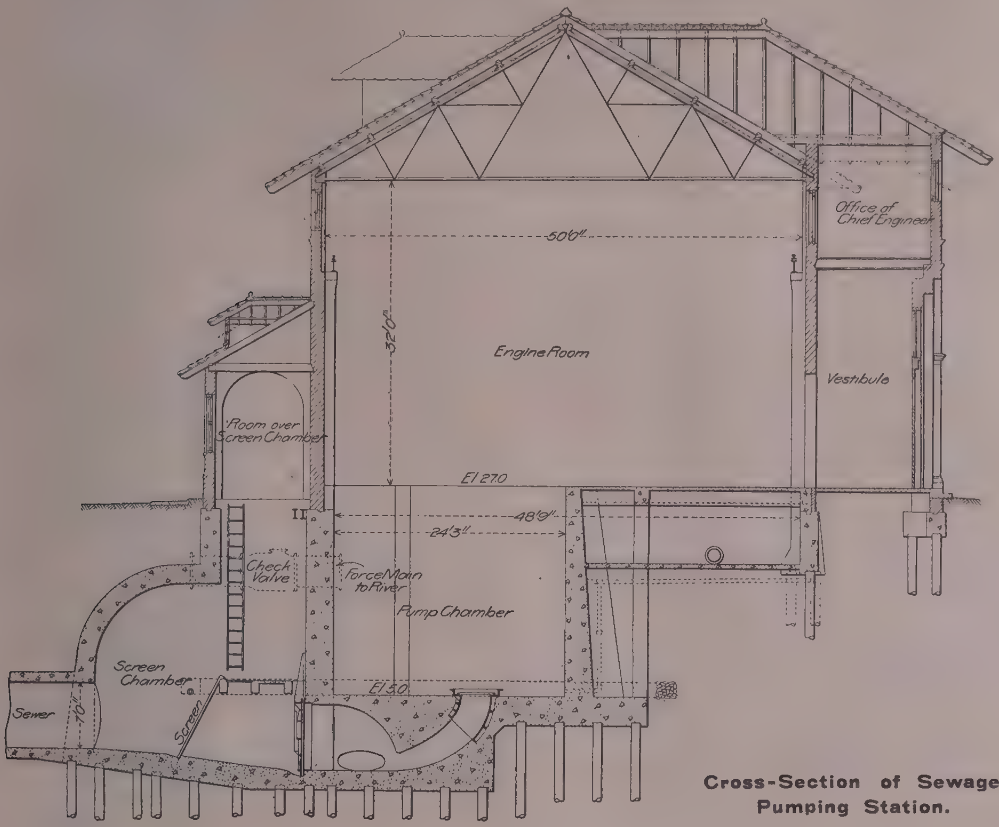


Manhole Used on Main Sewers.

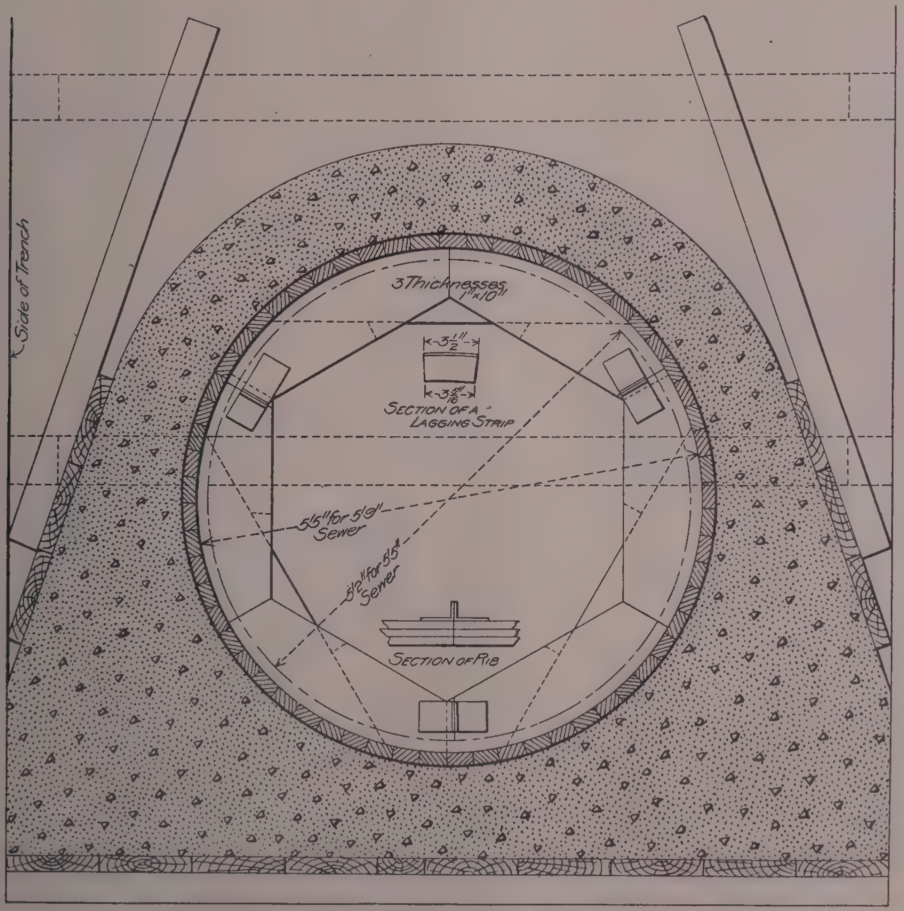


Manhole on Pipe Sewers.

ate low-lift stations on the line of the main sewers is much the same. An accompanying cross-section and plan of Station 14 shows the sewer connections and method of placing the pumping equipment in that station. This station is 3½ miles from Station A, on the uptown main sewer leading to the latter. The main sewer is 4 ft. in diameter at the station, which is at the junction of a 27-in. sub-main with the 4-ft. main. The station is installed to lift the flow from the 4-ft. and the 27-in. mains and discharge it into a 4.25-ft. main at a higher elevation. The station consists of a heavy concrete pump pit, 26 ft. in diameter and 23.5 ft. deep below the surface, with a wet well at one side into which the 27-in. and 4-ft. sewers discharge. The pumping equipment being installed in this station consists of two horizontal centrifugal pumps with a capacity of 710 cu, ft. a minute, which are placed on the bottom of the pump pit. The suction pipes of these pumps extend into the wet well. The pumps discharge into a wet well on the opposite side of the pump pit, and the 4.25-ft. sewer leads from this well. Each pump is direct-connected to a 30-h.-p. induction motor on the floor of a building erected over the pump pit. Space is provided in the pump pit for the ultimate installation of two more units of the same capacity as those that have been installed.



Cross-Section of Sewage Pumping Station.



Forms for a 5-Foot 9-Inch Sewer.

The amount of sewage to be discharged by the first lift stations serving collecting areas is quite small, varying from 400 to 800 gal. per minute for the immediate present to an ultimate estimated flow of 1,000 to 4,500 gal. These stations are arranged and equipped like Station 14. Space is in all cases provided for the ultimate required pumping equipment. The pump pits and wet wells of each station are generally covered with a flat reinforced-concrete slab, the top of which is below the street grade and covered with earth. Entrance to an operating and machinery floor over the pump pit is furnished through a manhole in the slab covering. This manhole is in the sidewalk and is built up above any possible flood level.

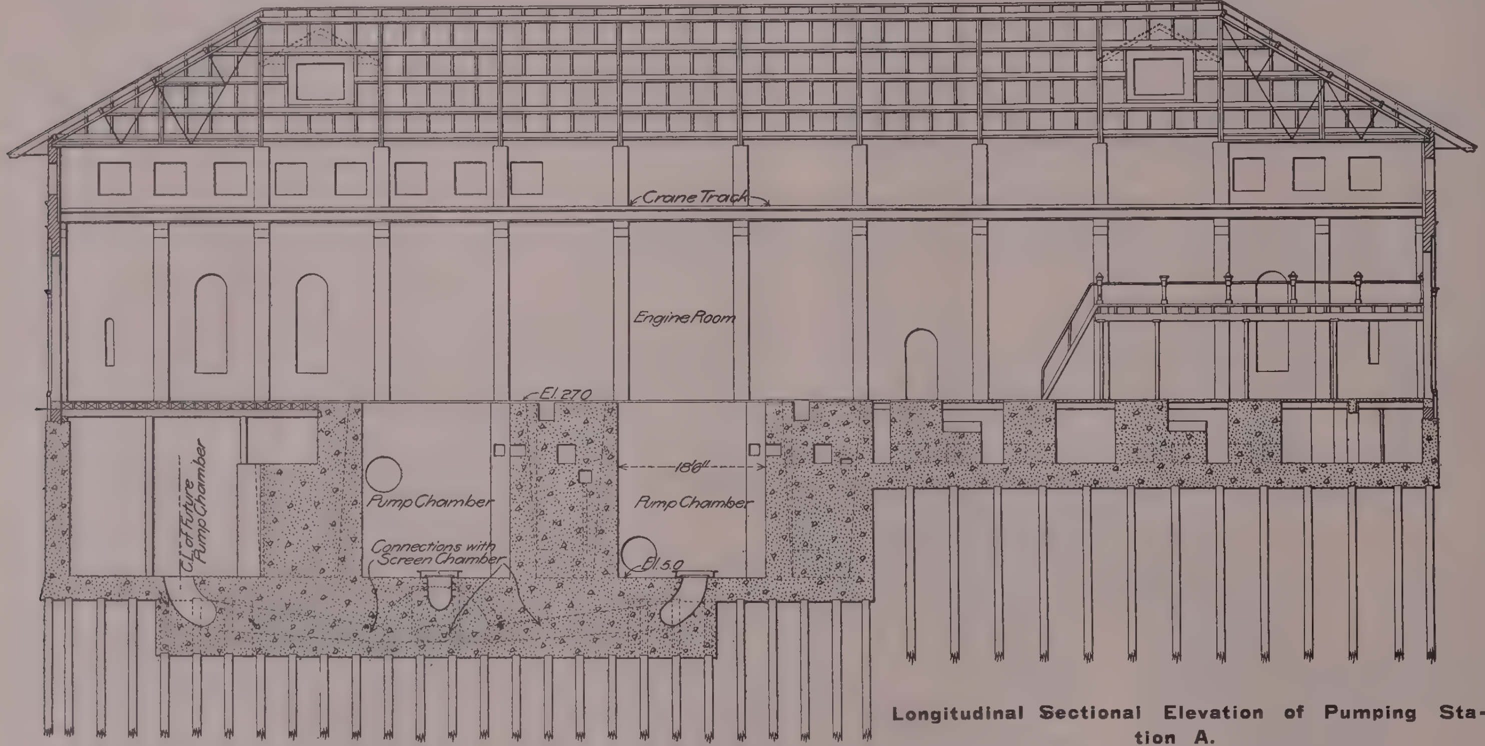
The natural conditions of the soil and the existence of the ground-water plane so close to the surface might readily be expected to present unusual difficulties in the construction of a sewerage system in which considerable depths cannot be avoided. Few difficulties were encountered, however, other than those which are presented in making excavations in a wet soil. While the water plane is high and the stage of water in the river is at times higher than the ground in practically every part of the city, excavations in most of the area that has been sewered are nearly free from water when first opened. The soil gives up its water very slowly, but if an excavation is left open for a few days the water will rise in it to the level of the ground-water plane. Practically all of the deep and many of the shallow trenches had to be heavily sheeted. Still, a large amount of trench has been opened and the sewers built in it with only skeleton sheeting. The comparatively deep pump pits at some of the pumping stations required the most difficult pieces of excavation that were undertaken. These were successfully made and piles driven in the bottom of all of them to carry the load of the concrete lining of the pit and the machinery. Owing to the careful sheeting and bracing of all excavations, comparatively little damage has been done to adjoining buildings, even where trenches of the large mains were excavated to a depth of 18 to 24 ft. in streets along heavy brick and stone structures.

A variety of machinery, including Carson, Moore and Potter trenching machines, has been employed in making excavations in different parts of the sewerage system. Cableways have also been set up longitudinally over the trench in a number of places, handling the excavated material in buckets from the point where the trench was being opened to the point where it was being backfilled. Owing to the great density of much of the saturated soil encountered in places, this method had to be followed carefuly to avoid breaking pipe sewers in backfilling. The viscous nature of some of the soil also caused the latter to stick badly in the buckets and on dumping boards. These conditions were likewise detrimental to the operation of excavators spanning the trench and handling buckets filled with excavated material.

A collapsible form for concrete sewers, devised by Mr. Victor Windett, of Dowdle & Windett, contractors for the central section of main sewer from Station A, is shown in an accompanying illustration. The form shown is for a 5-ft. 9-in.

sewer, but the same type was used on sewers from 3.5 to 5.75 ft. in diameter. The forms were built in sections 6 ft. long. The centering for each section consisted of three ribs, one near each end and one at the middle of the section. Each rib consisted of three thicknesses of 1x10-in. plank, nailed together and dressed to a true circle on the outside. The ribs of the forms were built in three parts, as shown in the reproduction of the drawing of the form. One side of each end of the three parts was fitted with an angle made of a 4-in. strip of ¼-in. galvanized sheet iron. The projecting legs of the angles on the adjacent ends of adjoining parts of the rib fitted together, back to back when in place, and were fastened together with pins. The lagging consisted of 2x4-in. pieces in 6-ft. lengths. The sides of these pieces were dressed on radial lines of the circular section of the sewer when in place. The lagging was held in place on the centering by wire wrapped around the outside of the form at the ends and held by staples driven in the lagging. The forms were ocasionally coated with hot paraffin to prevent the mortar from sticking to them.

The concrete in the base of the sewer would first be built up to a few inches above the invert of the sewer barrel without any forms, except a template for the invert. A key was made in the top of each side of this base by placing a 2x4-in. piece of lumber longitudinally in the fresh concrete. As soon as convenient the sections of forms for the sewer barrel were built up on the ground and lowered into the trench. The concrete in the remainder of the sewer barrel was then laid. The sections of the forms were collapsed by pulling the pins holding the angles on the pieces of ribs together, the lagging readily falling when the ribs were removed.



Longitudinal Sectional Elevation of Pumping Station A.

The two 36-in. flexible cast-iron pipes at the end of the force main from Station A required considerable care in laying. The outer end of each pipe was first assembled on a scow lying along the wharf under which the land ends of the flexible pipes are supported. A tackle was then fastened around the vertical leg of each pipe and fastened to a block and fall on a set of timbers cantilevered out from the wharf. The outer end of the pipe was blanked and swung from a derrick scow. The pipe was then gradually lowered into position, the inner lengths being added one at a time as the outer leg was lowered. A suction dredge excavated a trench in the river bottom to receive the inclined leg of the pipe as it was lowered. The two pipes were thus assembled and lowered with the assistance of a diver without an accident. Each length assembled and swung weighed about 15 tons, and the current in the river was about 3 miles an hour during the work.

The full benefit of the sewerage system will not be available to the city until the extensive municipal water-works system now under construction is completed. The value of the sewerage system in the meanwhile can hardly be over-estimated. The lowering of the ground-water level by such pumping as has been required during the construction of the system is already very evident in many places. When the system is fully in operation, this water level will doubtless be lowered until a marked effect is produced on the health of the city. The removal from the street gutters of kitchen, bathroom and other household wastes will be possible as soon as the system is in operation and this possibility will alone justify the completion of the system before the service of the water-works system is available.

The sewerage system was designed originally by the staff of the private company previously mentioned, but its details have been worked out by the engineering department of the Sewerage and Water Board of New Orleans, assisted by its Advisory Board of Engineers. Mr. George G. Earl is general superintendent, Mr. W. T. Crotts is assistant general superintendent, and Mr. John T. Eastwood is principal assistant engineer of the sewerage and water pipe system. Mr. J. W. Armstrong is principal assistant engineer of the pumping and purification stations for the water works. The general contract for the equipment of the pumping stations was awarded to the Camden Iron Works, of Trenton, N. J. The contracts for the bulk of the trenching and sewer building were awarded to the following contractors: Dowdle & Windett, of Chicago; R. C. Storrie, T. J. Shea, of Quincy, Ill.; Irwin Bros., of Greenville, Ohio; A. L. Patterson & Co., of Macon, Ga.; Bryne & McKnight, of Toronto, Canada; Black & Laird, of Birmingham, Ala.; G. R. Turner, of New Orleans. The main pumping station was built by Wren & Co., of New Orleans.

The Disputed Features of the Panama Canal.

A Communication from Mr. W. Henry Hunter, chief engineer of the Manchester Ship Canal, to the Senate Committee on Interoceanic Canals.

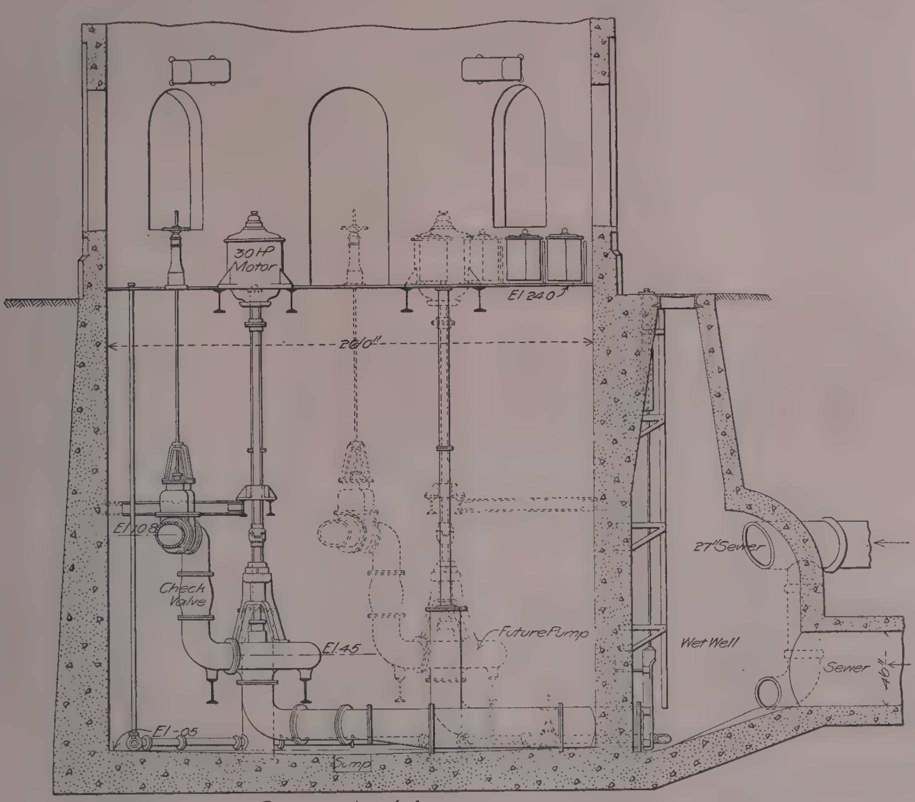
As a member of the Board of Consulting Engineers, I took part in the exhaustive investigation into the merits and demerits of the various types of canal proposed for the interoceanic waterway on the Panama line, and consequently became convinced that it was my duty to support the proposal for the construction of a canal at sea level, and to subscribe to the recommendation to the United States Government and to Congress as to the adoption of the sea level type of canal. A careful study of the report presented by a minority of the members of the Board has confirmed me in the opinion which I formed.

After considerable experience, not only in the construction but also in the operation of maritime waterways, it appears to me to be clear that the paramount consideration in the discussion as to the type of the Panama Canal should be the provision of a waterway which will, so far as human effort can secure such a result, be absolutely safe as a navigation, and therefore shall not present any peculiar hazards to the traffic, and shall not include any inherent features which may make for disaster to vessels in transit, and for the destruction of the works when completed.

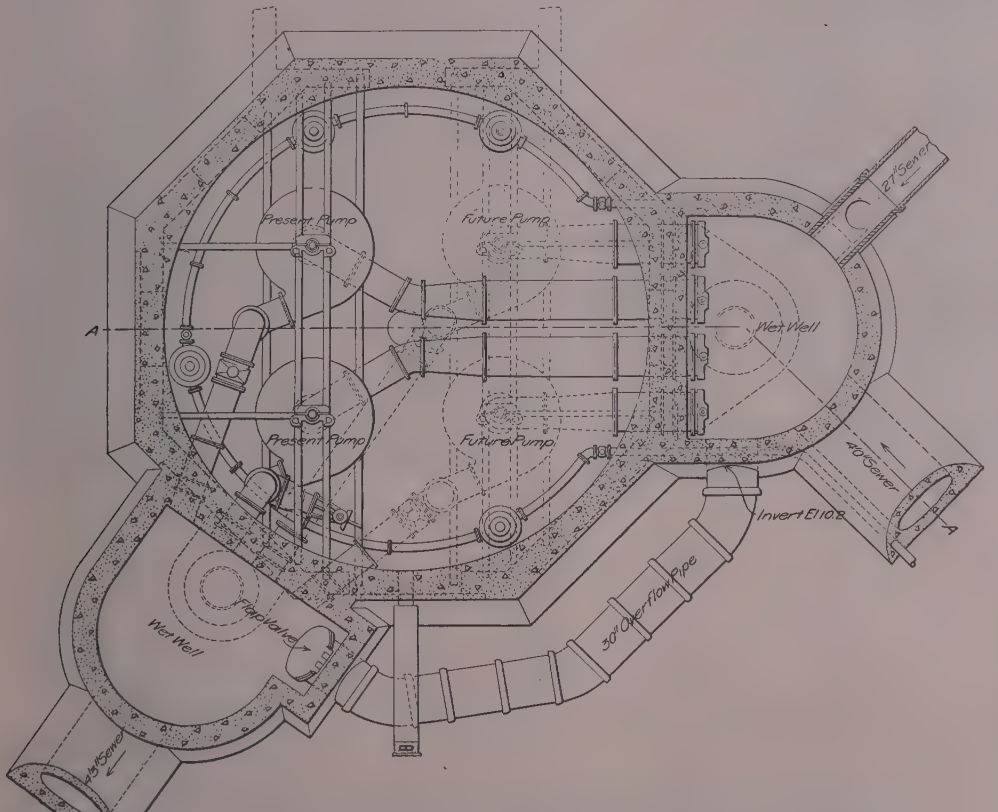
Safety of navigation requires (1) that the canal shall be free from obstruction, and (2) that it shall not be dependent for its existence upon the maintenance and preservation of works of art of an experimental character.

It is impossible to deny that the employment of locks of great size, and particularly of lifts of height beyond all precedent in engineering practice, will mean that the canal will, during the period of its existence, be cumbered by obstructions which can neither be avoided nor removed, and which will put every line-of-battle ship and every large commercial steamer into peril on each occasion upon which any such vessel will traverse the Isthmian waterway.

Accidents to Locks.—Minor accidents at and to locks are of daily occurrence; they are incidental in their nature and have but an unimportant bearing upon the question which is being considered by the Committee. Accidents of another sort, however, by no means of a minor character although still incidental to lock navigation, must be contemplated, not merely as possible but as inevitable, i. e., accidents arising from collisions between moving vessels and the gates of the locks.



Section on Line A-A



Plan and Sectional Elevation of Sewage Pumping Station 14, New Orleans, La.

Of such accidents I have had personal and painful experience, and submit for the information of the Committee, the following list of certain of the more serious examples thereof, premising the list by stating (a) that the Manchester Ship Canal was opened for traffic in 1894 (b) that there are on that canal four groups of lift locks (as distinguished from the tidal locks at the junction of the canal with the estuary of the Mersey), with two locks in each group, the dimensions of one lock being 600 ft. by 65 ft., and of the other 350 ft. by 45 ft., and (c) that the respective lifts of the locks vary from 13 to 16 ft., the depth of water on the sill of each lock being 28 ft. The maximum depth of water against any one pair of gates is therefore 44 ft.

In each of the cases in this list, except the first, where the collision was due to mismanagement, the accident arose from a cause which it is impossible to guard against, that is to say, from the fallibility of the human organism as a working mechanism, as the engineer in charge of the engine room being ordered from the bridge by telegraph to go astern with his engines, went ahead, and in two of the cases where the order was emphatically repeated "full speed astern," repeated his error with equal emphasis and went full speed ahead.

In the minority report, it is proposed, not to eliminate this inherent and overwhelming peril of lock gate destruction, as it appears to be recognized that this is impossible, but to obtain "a great degree of security" by the provision of "a long solid pier with suitable snubbing posts" at each end of each lock. The distinction between theoretical dissertation and practical experience in the matter at issue may be illustrated by the fact that in each case in the foregoing list, except the first, the vessel had actually entered the lock in safety, that her mooring ropes had been passed out on to the lock walls, and that she had therefore proceeded beyond the point at which the "long pier" (which should not be solid) would render undoubted assistance in the navigation of vessels where approaching a lock.

List of Accidents to Lock Gates on the Manchester Ship Canal.

Date.	Name and Tonnage (gross) of Steamer.	Name and Size of Lock.	Result of Collision.
April, 1895.	Harold,	Latchford,	Intermediate gates destroyed and carried away.
Nov., 1899.	Starlight, 1481 tons.	Barton, 65 ft.	Lower gates destroyed and carried away.
Dec., 1902.	Winkfield, 4009 tons.	Barton, 65 ft.	Lower gates destroyed and carried away.
June, 1904.	Taunton, 366 tons.	Latchford, 45 ft.	Intermediate gates destroyed and carried away.
Jan., 1906.	Barbro, 779 tons.	Mode Whl. 45 ft.	Lower gates wrecked.

Another suggestion in the minority report, by which it is hoped that the disastrous consequences which would follow the striking of the lock gates in the Panama Canal by a large vessel might be alleviated, relates to the provision of additional gates at the ends of each group of locks. I am decidedly of opinion that such provision would, in the occurrence of the event, make bad worse, as the probability is that the result would be that not only two pairs of gates would be wrecked instead of one, but that the vessel herself would be sunk in the lock.

A still further proposal made to the Senate Committee by one of the witnesses heard in support of the lock type of canal was that "a temporary structure could be sunk down in the foundation just ahead of the upper locks, so that in case anything happened below you could raise it just like one of the Stoney gates." I have great respect for the distinguished officer from whom this proposal emanated, and therefore abstain from comment on the astonishing device suggested by him.

The results which followed the accidents to the lock gates on the Manchester Ship Canal were unfortunate enough, but happily in each case the disaster which impended was averted, as the men in charge of the lock, recognizing the danger, displayed much presence of mind and acted with such great promptitude that they succeeded in partially closing the upper gates of the lock before the rush of water which followed the wreckage of the lower gates took place. In this connection, however, it is, I admit, worthy of the Committee's attention, htat the resulting damage in the cases in which the gates of the 65-ft. locks were wrecked was out of all proportion to that which accrued in the cases of the gates of the 45-ft. locks. In the

65-ft. locks the gates struck were not only wrecked, they were carried clean away, while the upper gates were hopelessly damaged, and in two of the cases rendered absolutely unworkable. In the 45-ft. locks the gates struck were wrecked, but were only carried away in one case, while the upper gates received little or no damage, and continued to be worked as usual.

The inference to be drawn from this fact is that in the event of the gates of any lock being suddenly wrecked, the resultant damage will not only be greater in the case of a larger lock than in a smaller one, but will be much greater in proportion than the actual ratio between the respective dimensions of the two locks.

It is on the experience which I have recounted that I base my opinion that in the case of such locks as those proposed in the minority report, having a width of 95 ft., a differential head of water against the gates of from 28 to 30 ft., and a depth of water behind the gates of from 68 ft. to 70 ft.—if the gates are carried away by a downward bound vessel, no power on earth can stop the rush of water, that the velocity of the stream through the lock will be such that any vessel will be carried on thereby, and that if the occurrence takes place in the flight of locks proposed at Gatun, the vessel will plunge from step to step to destruction, while the group of locks will probably be wholly wrecked and the canal rendered inoperative.

Building a Concrete Sewer, New Orleans, La.

An Intermediate Pumping Station, New Orleans, La.

The conclusion which seems to be inevitable is that while the adoption of single-lift locks would lead to certain obstruction of and sensible peril to every large vessel navigating the canal, the acceptance of the proposal to build three locks in flight at Gatun would sooner or later lead to a disaster of which the ultimate results can only be imagined, as they would pass beyond the region of engineering estimate.

The group of locks at Gatun is described in the minority report as containing "the greatest mass of masonry built in modern times," and may further be described as presenting one of the most striking examples of rash and hazardous experiment in the construction of public works ever seriously suggested to the government of a great nation.

Dams.—A further experiment in engineering construction and one of an almost equally hazardous character is offered in the design of the earth dams at Gatun, on the Atlantic side, and at La Boca and Corozal, on the Pacific slope; particularly in the Gatun case, where the dam is intended to retain an artificial lake at an elevation of 85 ft. above mean sea level, and where the earth mound is to be based upon a mass of material which extends to a depth of 258 ft., and is of a character of which nothing is known beyond the meagre and easily mis-read facts revealed by the borings which have been taken at the site. Engineers of all countries, who are experienced in the conduct of public works, unite in their testimony in respect of the unreliable nature of the results obtained by boring operations, and of the necessarily uncertain (and often times misleading) character of the deductions which they attempt to draw from such results. Nothing is more common than to find, when ground which has been explored by borings is opened up, that it is necessary that designs for works, which were based upon information gathered from the boring journals and from study of the specimens preserved by the boring parties, shall be radically altered owing to the totally different nature of the stratification as proved by excavation work when compared with that which it was supposed, from the borings, would be found.

The Corporation of the Borough of Stockport, in Cheshire, are now carrying out works for the further supply of water to their district. I am concerned in the works—which will include three large earth dams for reservoir purposes—for clients who opposed the Corporation scheme and obtained protective clauses in the Act of Parliament by which the works were authorized. One of the dams is now in progress, or rather was in progress up to a few months ago. The site for the dam was explored by borings placed more closely together than those made on the line of the Gatun dam. The borings were made and the dam was designed under the auspices of one of the most capable and experienced waterworks engineers in the world, the late Mr. James Mansergh, F. R. S. When the trench for the core wall of the dam was sunk, it was discovered that the underlying material at the site differed so entirely from that which the borings led the engineers to suppose would be found thereat, that it became necessary to stop the works, and to reconsider the whole design of the dam, with the result that the Corporation has become involved in serious litigation with the contractor for the works.

What then can be said for such a proposition as that which would make the very existence of the Panama Canal dependent upon a mere mound of earth provided with neither core-wall nor cut-off, and based upon material which it is not intended even to prove by excavation, but which is assumed from the results of a few borings to be sufficient for the tremendous purpose which the dam is desired to serve?

The danger to be apprehended is that of subterranean erosion due to the natural tendency of water to follow lines of least resistance, with effects very familiar to those acquainted with the salt producing districts of Cheshire and Worcestershire in England. Such erosion may, and often does, proceed for lengthened periods without surface indication of its existence, while when the results of the subtle and obscure working do at last become apparent, it frequently happens that the mischief has gone too far—has become irreparable.

It is not suggested that an earth dam at Gatun is impracticable, or that such dam cannot be made reasonably safe. The enormous depths to rock render the formation of core walls impossible, but I am of opinion that an effective cut-off may be designed and carried out which will arrest percolation and stop erosion, and consider that if this cut-off be introduced, and if the design of dam suggested by the late Mr. Morison and subsequently by Major Gillette be adopted, even such a head of water as 85 ft. could safely be retained, but if these alterations be embodied in the plan proposed in the minority report the estimates of cost must be largely increased, and the estimate of the time required for the construction of the canal must be extended by several years.

The questions relating to the dams at the Pacific terminus are of a less serious nature than those connected with the dam at Gatun, as (1) the proposed elevation in the Sosa Lake is only 55 ft. instead of 85 ft., and (2) the borings indicate that it may be expected that clay or rock will be found underlying the soft greasy mud at the sites. The special danger to be provided against, particularly in the case of the dam at La Boca, is that the whole structure may slide down the clay slope towards the sea on the bed of greasy mud upon which it is suggested that it should be based. This danger can be provided against by the formation of a substantial core wall, which should be carried well down into the clay or rock so as to form a key therewith, and then if the clay or rock prove to be as good material as is indicated by the borings, it may be hoped that the dam will stand. The only possible reason for the omission of so obvious a precaution from the design is that the core wall will add considerably to the cost of the dam, and will also extend to a sensible degree the period required for the formation thereof, and that if this and the other additions be made to the works proposed for the lock type of canal which are required in order to render the canal safe from the point of view of construction as distinguished from that of operation, the present exaggerated difference between the estimates of cost for the sea-level and lock types will be reduced almost to insignificance.

Bracing and Sheeting in a Pipe Trench, New Orleans Sewerage System.

Stumps Encountered in Old Cypress Swamp at New Orleans, La.

Lake Navigation.—The case for the introduction into a work of such world-wide importance as the Panama Canal (which should, above all things, be characterized by simplicity of design) of structures so unprecedented in magnitude and so experimental in character as the groups of lift locks and the dams recommended in the minority report, is founded upon the advantages which, it is considered, will accrue if part of the line of the canal be converted into "lake navigation." I respectfully submit that, while the advantages of the so-called "lake navigation" are largely sentimental or imaginary, two very real and practical dangers will be presented to shipping while traversing the artificial pools proposed to be formed by the earth dams.

The first danger will at certain times be encountered on the sheet of water to be retained by the dam at Gatun, of which the area will be 110 square miles and the elevation 85 ft. above the sea level.

Abundant evidence was laid before the board as to the effects of the severe storms of wind—hurricane-like in intensity—which on occasions towards the end of the year sweep down suddenly from the Caribbean Sea, strike Limon Bay and the country adjacent thereto, and deal destruction upon any vessels which may not have succeeded in reaching the open sea before becoming exposed to the effects of the "norther."

The Gatun dam will only be about three miles from the head of Limon Bay, and the lake retained by the dam with its great elevation will be absolutely unsheltered from the fury of the "northers," while the lines upon which the channel through the lake are proposed to be formed are unexampled in their extraordinarily abrupt changes of direction, changes which recur from time to time in the devious course of the channel, but which are particularly marked at and about 11 miles, 16 miles, 17 miles, 26 miles, and 27 miles. The conclusion is irresistible that a steamer upon which a "norther" broke while she was attempting to navigate the acute angles presented by these tortuous bends would have a meagre chance of escaping total loss.

The second danger will be much less serious in degree, but will be perennial—will be always present. Members of the Committee who have visited the Isthmus will remember the appearance of the landscape which presents itself to a spectator standing on the foot-hills near Gatun, and looking over the immense tract of country which it is proposed to submerge by the waters to be retained by the Gatun dam. With small exceptions the whole area is occupied by dense tropical vegetation. Trees of different species, some of great size, cane brakes, and jungle-like undergrowth clothe the hills and the valleys with an impenetrable covering. It is not proposed that any attempt should be made to clear the site of the lake from this herbaceous obstruction. Such a proposal would be impracticable, it would be in the nature of an attempt to translate the legendary labors of Sisyphus into more costly but equally futile efforts in modern life. It is doubtful whether it will be found possible to clear even the lines of the submerged channels owing to the extraordinary rapidity of growth in an atmosphere so humid as that of Panama. The flooding of this great area will produce a submerged forest, every tree and shrub will perish, will, as experience has shown, ultimately fall, and the result will be that an unlimited supply of waterlogged snags will be provided, which will furnish obstacles of the sort which are viewed with more dread than any other by those responsible for the safe passage of vessels along waterways, as the snags neither float nor sink, but are carried to and fro in the water, and as nothing can be done either to determine the whereabouts of the invisible obstructions or to protect shipping from contact with them.

The presence of such unseen obstacles will render it essential for steamers, for the sake of their propellers, to crawl through these lake navigations instead of steaming full speed ahead as the authors of the minority report appear to imagine. Should any of the honorable members of the Committee think that this account is overdrawn, I beg respectfully to suggest that they will call for particulars of the present condition of the embayment on the Atlantic side into which the Rio Chagres discharges, and which I, together with two other members of the Board, had an opportunity of viewing when in Panama.

Speed of Vessels.—I observe that various estimates of the speed at which the ordinary large commercial steamers of the day can traverse channels of the dimensions proposed for the sea-level canal have been presented to the Committee. It has been asserted that the speed would not exceed four or five miles per hour. Others have ventured on higher estimates, but have contended that passing places must be provided, and that when vessels meet one must be moored at the side in order to permit the other to pass.

The minimum width proposed for the prism of the sea-level canal is 150 ft. at a depth of 40 ft., and with a flat slope on each side, or 200 ft. with a similar depth when the sides are vertical.

The ruling width of the Manchester Canal is 120 ft. at a depth of 26 ft. Ten years ago steamers of 6,000 or 7,000 tons did crawl along that canal at rates something like those suggested to the Committee. But increased experience has brought with it greater wisdom, and steamers of 10,000 to 12,000 tons dead weight capacity now traverse the waterway at speeds of over eight miles an hour, while smaller steamers travel at considerably greater speeds.

With the greatly increased section of the Panama Canal, the Committee may feel assured that the every day speed for all commercial steamers, except those of the very largest dimensions, will be from eight to ten miles per hour, and that no vessel will be moored for the mere purpose of allowing another to pass her. When steamers meet both will slacken speed somewhat, and so will pass each other without difficulty or danger.

There is no advantage to be gained from excessive width of channel, except, indeed, such as may be measured by a very slightly diminished consumption of fuel. Vessels will use a little more coal while steaming at ten miles per hour in a channel with a bottom width of 150 ft., than while steaming at the same speed (omitting for the sake of comparison the question of snags and other submerged obstacles) in a channel 1,000 ft. wide, but skilful and competent canal pilots would assure the Committee that the vessel is as easily and safely handled in the one as in the other. And in this connection account should be taken of the easy and regular curvature proposed for the sea-level canal, as contrasted with the sharp contortions of the submerged channels in the plans attached to the minority report.

Time and Cost of Construction.—Turning to the questions relating to the estimates for the two projects, (1) of the time required for construction, and (2) of the cost of such construction, I may be permitted to say that when in Washington, engaged in the work of the Board of Consulting Engineers, I gave much attention to the estimates, under both heads, relating to the sea-level project; and that I am confident that if the Government of the United States will place the work required for the execution of that project in the hands of enterprising and energetic contractors, whether individuals or firms, contractors of extended experience and of large capital resources (and there are numbers of these to be found in the United States), that the sea-level canal can be completed and opened for traffic within ten years from the date at which the various contracts shall be signed. This can be accomplished if the operations are confined to the daylight hours. If work is carried on at night, and there is absolutely no reason why, so far as the excavation is concerned, this should not be done, the ten-year period may be shortened.

It is agreed on all hands that the duration of time required to complete the excavation of the length of eight or nine miles of the canal, commonly known as the Culebra Cut, will furnish the measure of the time required for the completion of the sea-level plan, as from that length a quantity of excavation amounting to 110,000,000 cu. yd. is to be removed, and as the removal of such quantity will be the major operation in the execution of the project.

It seems unnecessary to consider further the schemes for the removal of a part of this excavation by means of dredging operations; such schemes are wildly chimerical, and are based upon no experience. The excavation must be effected in the dry, and I beg leave to refer to the diagram showing the manner and times of its removal, which is appended to the report of the Board. (See Eng. Record, Feb. 24, p. 218.)

In the preparation of the diagram it was assumed that there would be no limitation of plant, that all the plant which would reasonably be required would be furnished. It was further assumed that the ordinary working year of a steam shovel of 300 days would be reduced to 240 days owing to the climatic conditions of the Isthmus, and that owing to the same cause the daily output of each shovel—working during the day only, no night work having been included in the calculation—would not average more than 800 cu. yd. That is to say that the annual average output of steam shovels of the exceptional size and power of those about to be employed in Culebra would not be more than 192,000 cu. yd. These figures are beyond the scope of reasonable and unprejudiced criticism, especially when the allowances made in the diagram for delay in getting into full work at the outset of the contractors' operations, and for diminution of output towards the close of those operations are duly considered, and they show that the excavation of the Culebra Cut can be completed in nine years.

Lowering a 36-Inch Outfall Pipe from Station A, New Orleans, La.

I have added a year to this term for contingencies, and have thus arrived at the time of ten years for the completion of the sea-level canal, as to the feasibility of which I have expressed, and do again express, so confident an opinion.

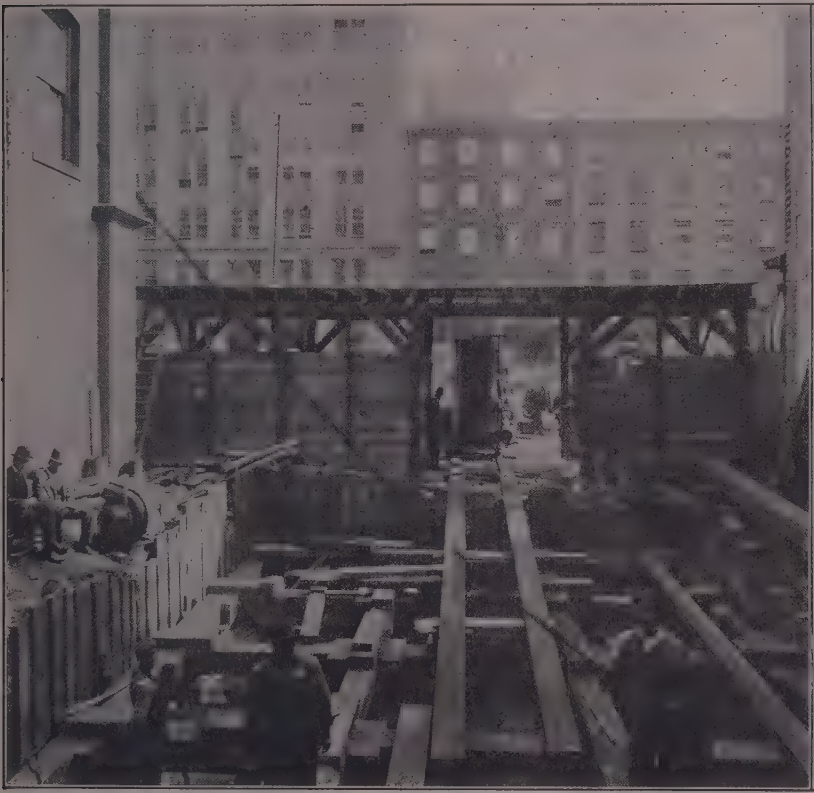
On the other hand when the time required for the work required to make the dams at Gatun, La Boca, and Corozal reasonably safe is taken into account, and when also the immense difficulties, in respect both of transport and of skilled labor, which will be involved in any attempt to build concurrently six huge locks at three different sites, containing in all some 3,000,000 cu. yd. of concrete and masonry (I think that the estimated quantities for these works contained in the minority report would be found to be insufficient) are duly weighed, that it must be admitted that the estimate of time required for the completion of the lock canal scheme with elevation of 85 ft. must be very largely extended.

There remain the questions relating to the estimates of cost for the rival projects.

So far as the estimates for the sea-level canal presented by the Board are concerned, the criticisms—if arbitrary assertions, for which not one scrap of evidence or suggestion of warrant has been produced, can justly be described as criticisms—have related mainly to three points of detail: (1) The unit price of the excavation below El. 10 in Culebra; (2) the cost of the works for the regulation of the minor streams; (3) the omission of allowance for the provision of passing places.

As to (1). The difference in cost between the excavation above El. 10 and the excavation below that level will be due to two main factors. (a) The material excavated below El. 10 will have to be hauled up inclines to the dumps, and (b) during the removal thereof pumping will probably be required to keep the cutting dry. If the inclines are formed on a grade of 2½ per cent., two engines will be required to do the work on the incline which one will perform on the level. The cost of the formation of the inclines and of the extra hauling power may reach 10 cents per cubic yard. Pumping under the Isthmian conditions will probably cost another 5 cents. The total difference is therefore about 15 cents per cubic yard. The Board priced the excavation above El. 10 at 80 cents, and that below El. 10 at $1.25, a difference of 45 cents instead of 15. It is suggested that the difference should be $1.70. The only observations upon which I venture in respect of the suggestion are that the line dividing the excavation above El. 10 from that below El. 10 is a purely imaginary one, and that the sensational difference in unit price suggested for the removal of material above and below that line seems to have been due to some confusion of mind as between the removal of rock in the dry in an inland cutting, in which some pumping of drainage water will be required, and the removal of rock under water, on the part of gentlemen who possibly are not familiar with either operation.

As to (2). Much unnecessary apprehension has been expressed, both as to the effect and as to the probable cost of the works required for the regulation of the side streams which will flow into the sea-level canal. The works will be very simple in their design and very direct in their operation. No elaborate systems of masonry construction, for the purpose of converting the streams into cascades, will be required or need be contemplated. It will suffice if the streams when not diverted altogether, whether higher or lower in level (as compared with the level of water in the canal, are in each case allowed to fall directly into a pool to be formed at the foot of each, from which pool the water will flow over a weir into the canal, the short channel from the weir being laid out on such lines and at such depths as will reduce velocity to the point required, to eliminate appreciable current. This, in principle, was the method adopted for dealing with the flood waters from the river Mersey which pass into the Manchester Canal, and has, in practice, proved to be entirely successful, as even in time of very heavy flood, when the quantities discharged from the Mersey are much greater than those which will be discharged from any of the subsidiary streams on the line of the Panama Canal, the current velocity in the waterway never exceeds two miles per hour, which velocity has had no effect whatever upon passing steamers, whether moving with or against the current.



Completed Sheet Piling and Upper Tier of Bracing.

Removing Crib Stone from Under Feet of Piles.

I shrink from prolonging this already lengthy letter by any discussion of details, and therefore only add that in my opinion the amounts included in the estimates, for the works for the regulation of the side streams, will be found to be sufficient.

As to (3). No widenings of the canal prism for passing places will be required, and therefore no addition to the estimates need be made for their formation. I speak with confidence as to this, as while the ruling width of the Manchester Ship Canal is 120 ft. at a depth of 26 ft., one length of the canal, from Barton to Manchester, has a bottom width of 170 ft. at the same depth. The narrowest prism for the Panama Canal will be at a depth of 26 ft. and have a width of 192 ft. The experience which we have gained here as to the difference in the working of traffic in a width of 170 ft. as compared with a width of 120 ft., enables me to speak with the confidence which I have expressed as to the readiness with which it will be found that pilots in charge of steamers will pass each other on the still wider water of the Panama Canal.

Conclusions.—I think very decidedly that if the United States Government concludes to carry out the works for the Panama Canal at sea-level, through the medium of contractors, and will, while retaining the operation of the Panama Railroad in their own hand, render to these contractors reasonable facilities for transport, etc., and that if the provisions of the different specifications and the terms of the different contracts are drawn in a reasonable and equitable manner, the costs of the whole work ought to and will be found to fall below the total amount of the estimate submitted by the Board.

It cannot be denied that a lock canal, of whatever type, can be constructed at less cost in money than a sea-level canal. But when the estimates of cost contained in the Report of the Board and in the minority report are compared, and when to the latter are added the additional cost required (a) for removing the kinks from the line of the channel through the Gatun Lake; (b) for increasing the locks to the dimensions called for by the Spooner Act; (c) for adding cut-offs and core walls to the dams; (d) for clearing so much of the tropical growth from the areas to be submerged as will be absolutely necessary for navigation purposes, the difference between the two projects will be reduced to a capital sum, which will be insignificant when compared with the relative advantages and disadvantages of the projects; particularly when the volume of the traffic which must, in the natural development of the world's commerce and the inevitable increase in the world's population pass over the Isthmian Canal, be taken into consideration; as there seems no reason to doubt that the revenue from that traffic will afford a return satisfactory to the citizens of the United States for their expenditure on the waterway.

I apologize for the length of this communication. The subject is one in which I have taken a deep interest, and, in expressing my opinions on professional questions connected therewith, which relate to matters which have to a large extent formed my life work and upon which my opinion has been desired, I am sure that it will be understood that I have no object in view beyond that of serving the Committee of the Senate and of discharging my personal responsibility as a member of the Board of Consulting Engineers.

Steel Cofferdam for a Hudson River Tunnel Shaft.

An elevator shaft for the passenger entrance to the Hudson tunnel between Jersey City and Manhattan is now under construction in the rear of the Pennsylvania Railroad Co.'s trainshed in the former city. It is 32 ft. wide by 40 ft. long, and will have a total depth of about 60 ft. The first 30 ft. is through mud, fill and debris, extending from a level just above high tide to the rock. In order to excavate this it was necessary to build a cofferdam for which steel sheet piles of the United States pattern were selected. A 32x40-ft. horizontal rectangular framework was built on the surface of the ground with 12x12-in. timbers braced with four lines of transverse and three lines of longitudinal struts, all connected together by pairs of cover splice plates and end bearing pieces, thoroughly bolted, as shown in the general view.

Around the outer edge of this framework there were driven with a 2,500-lb. drop hammer, 144 pieces of sheet piling 30 ft. long. These interlock and, with the four pieces curved 90 deg. at the mill to form corners, make a continuous steel wall reaching from a point about 1 ft. above high water to the surface of the rock. After the excavation is completed, it is intended to line the shaft with concrete walls built up against the steel piles; as these will not be removed, no provision was made for pulling them and special care was taken to make the joints very close in order to insure perfect tightness without regard to friction between the adjacent members. The flange member of each joint was first driven and the socket member driven over it with a full length semi-cylindrical strip of white pine secured in it by a plug at the top, thus forming a packing which swells tight when exposed to the water.

The piles were driven at an average rate of about 14 daily and went down very easily except where they encountered the remains of several cribs. Two of these were of timber filled with earth and presented no serious difficulty, the piles cutting in one case through three 16x16-in. timbers without any trouble. The third pier, which extended across one end of the shaft, was filled with large riprap stone which no piles could penetrate. Here the piles were driven down until they encountered the stone and then excavation was carried down in the shaft until the stones could be gradually worked out from under the feet of the piles and the latter driven down with light blows of the hammer. In this manner they are gradually being carried down to the required depth and it has been found possible to keep them well driven, so that the water entering below their feet is handled by a single 6-in. centrifugal pump working only part of the time. Operations are suspended during the night, when the pit fills with water. This is easily pumped out in about one hour in the morning. The horizontal frame around which the piles were driven serves for upper waling pieces. Another one similar to it has been built a few feet below and a third one will be placed between it and the bottom of the shaft.

About one-half of the piles were driven by an ordinary land pile driver with a 50-ft. tower. The remainder of them could be reached by a derrick on one side of the shaft and they were, therefore, driven by the hammer working in leads suspended from the derrick boom, which proved more convenient than moving the pile-driving machine. The piles are driven with a cast-iron follower head, 17 in. in diameter and 8 in. deep, with jaws on opposite sides to engage the guides of the leads. The lower face of the head is provided with two sockets made to engage the end of a pile with plenty of clearance. These sockets are at right angles to each other, so as to receive a pile either parallel or perpendicular to the leads and thus provide for guiding it in either position. They do not, of course, fit the bent piles used for the corner, and when the latter were driven it was necessary to insert a solid disc in the bottom of the cap to bear against the tops of the piles.

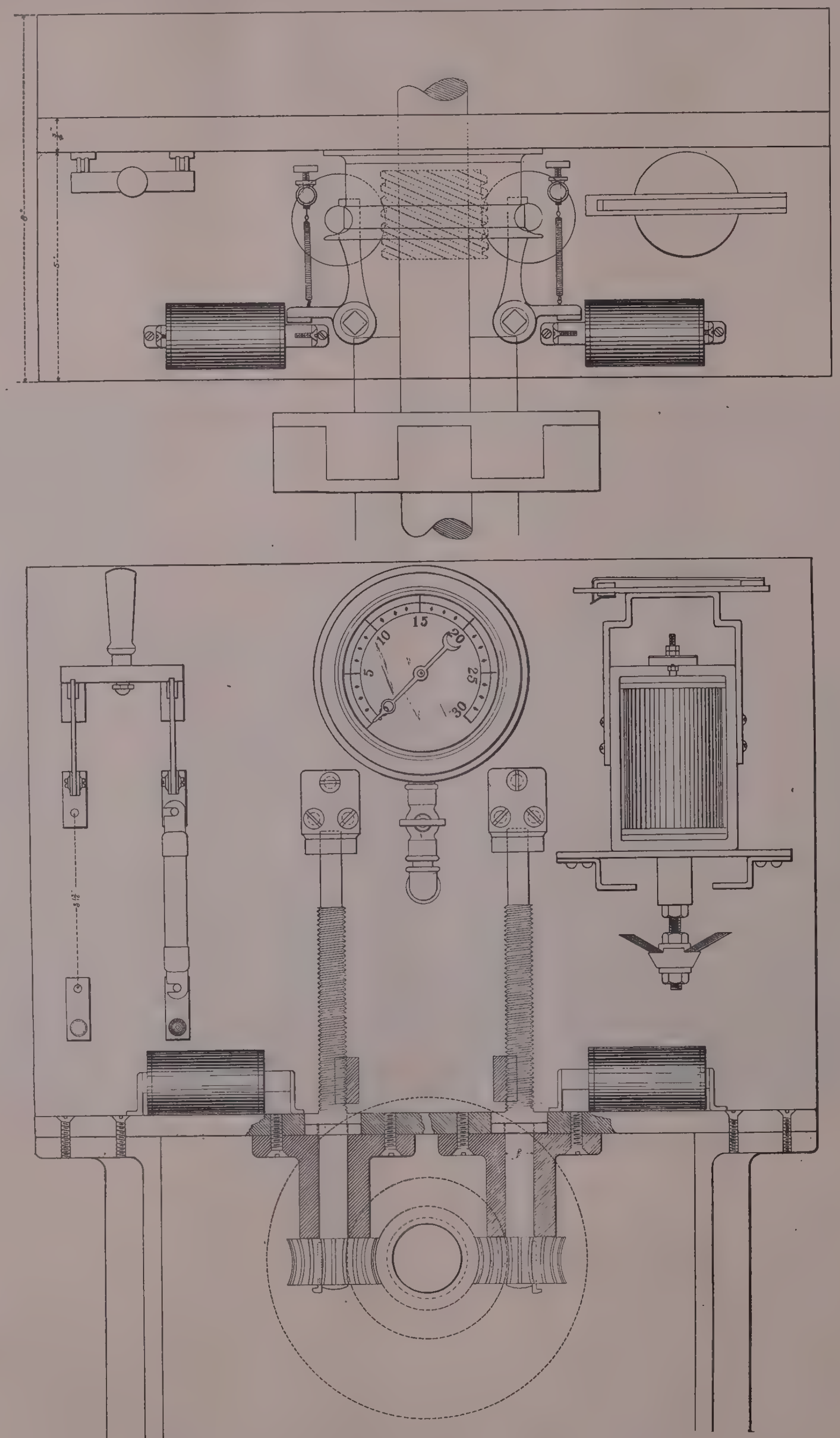
On the upper side of the cap there is a concentric tapered recess 12 in. in diameter and 2 in. deep, which receives a turned oak block on which the hammer strikes. The cap weighs about 600 lb. and has been used throughout the work without cracking. Its weight assists in the driving, and it entirely prevents battering the upper ends of the piles. It is seated loosely on the top of the pile and follows the lead, engaging the pile until the latter is completely driven. Chains are then attached to the hammer and to pins in the cap so that when the former is raised it will carry the latter with it and hold it ready to be placed on the next pile, after which the chains are removed and the cap remains on the pile independent of the movement of the hammer.

Mr. J. V. Davies is the chief engineer of the tunnel and shaft, and Mr. A. R. Archer is division engineer in charge of the work for the Hudson Company. The F. M. Stillman Co., Jersey City, are the general contractors, and 76 tons of sheet piles used for the cofferdam were supplied by the United States Steel Piling Company, represented in New York by Mr. C. B. Friday.

An Improved Pneumatic Tube System.

A new system of pneumatic tube operation has been introduced on some lines recently installed for the Postal Telegraph Co., between the Cotton and Produce Exchanges, and between the two exchanges and the Commercial Cable Co.'s building at 20 Broad St., in New York City. It has heretofore been the usual practice in the operation of such systems to maintain the pressure supply in storage tanks, which are drawn from as needed for the despatch of carriers. This system requires extensive pumping and air storage equipments, but in the new system special automatic blowing equipments are used which deliver air directly into the tube, but only intermittently, when needed, thus doing away with reservoir storage. This improvement involves the automatic starting and stopping of the blower every time a carrier is despatched through the tube, for which purpose an interesting type of motor-driven blower with automatic control mechanism has been devised.

The new pneumatic line on which this system is being used has 2¼-in. tubes to each point, over 6,000 ft. in all, the carriers traveling in one direction only in each tube. The lines have many sharp turns and bends owing to the complication of underground conduits and pipes to be avoided in the street, and the necessity of passing up through the available locations in the basements of buildings to the operating heads, there being as many as fourteen right-angle bends at one end. For the operation of the lines there is a special

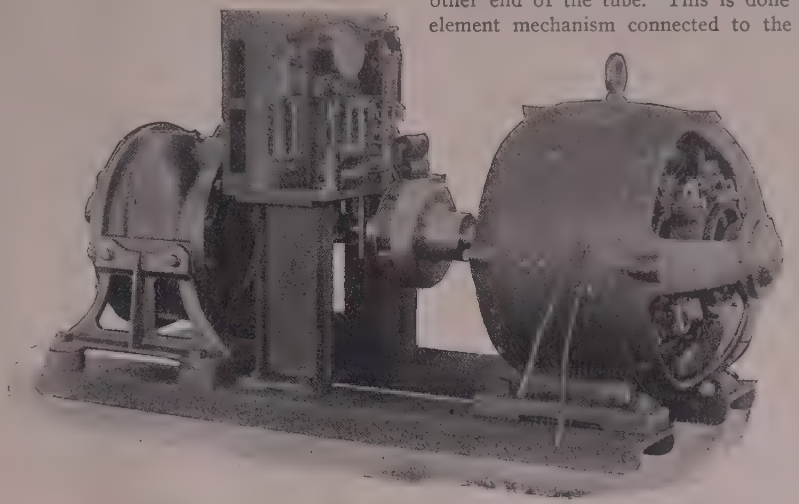


Details of the Time Limit Motor Control Equipment.

intermittent blowing equipment at either end, which is permanently connected to one tube, althought connections and despatching heads have been so arranged at both ends of either tube that changes may easily be made for despatching in either direction in either tube, or in case of disablement of either tube, of operating in both directions in the remaining tube. The scheme of operation embraces, in general, the use for every tube, of a blower equipment at the sending end with control apparatus in the tube head, so arranged as to start the motor automatically when the carrier is inserted and the head closed, and further automatic means for stopping the motor after the carrier has been delivered at the opposite end.

Each tube is fitted at either end with an operating head which enables it to be used for despatch in either direction, the equipment consisting of a despatch head and a receiving gooseneck and basket, either of which may be connected to the tube. In the accompanying illustration of a station in the Cotton Exchange, four tube equipments are shown, each with a bypass connection for allowing carriers to pass this station to other stations on the upper floor. Each incoming tube is connected through the floor to its operating head, the equipment of which is mounted on an A-shaped bronze frame, 42 in. high. The incoming tube has a ball and socket swivel joint at the floor line so that it may be swung to connect either to the despatching head, receiving gooseneck or bypass tube as desired. The joint is of special design so as not to interfere with the passage of carriers, and the connection is made to the despatch head, gooseneck or bypass tube by a special screw sleeve at the upper end of the 21-in. swiveling section of tube. When the operating head is used for a despatching station, the swivel tube is connected to the despatching box. When used for a receiving station, or bypassed, however, the swivel tube is connected through the gooseneck into a receiving basket of ornamental design, or to the bypass tube leading to a station upon an upper floor. The receiving basket is a bronze casting with a contour effective in bringing the issuing carrier to rest with the least possible shock.

The sending portions of the heads are rectangular brass boxes 9 in. long by 7 in. high, mounted on the A-shaped frame, with duplicate insertion doors and valve tubes connecting downward from the top. Air pressure from the blower is introduced in the outer portion of the sending box, and each inserting tube is fitted with a special grid valve so arranged that when the air-tight door on the top of the box is closed, a full air opening from the outer portion of the box is made to the upper part of the valve tube. Both of these inserting tubes discharge through a Siamese connection to the swiveling tube below, so that either inserting tube may be used. In operation the carrier is inserted into one of the valve tubes, and the air-tight door on the head closed down on it, which operation closes concealed electrical contacts within the box. This starts the blower motor and at the same time electrically locks the air-tight cover down over the tube, causing the air pressure to force the carrier to the other end of the tube. This air-tight door is released after the carrier is delivered from the other end of the tube. This is done by a time-element mechanism connected to the motor, by which it is closed down after having operated for a predetermined number of revolutions. It has been found as a result of experience that the despatch of a carrier through a tube 1,500 ft. in length requires only about 25 seconds, the greater part of which time is consumed in passing the large number of bends beneath the street and up through basements and partitions in the buildings. The motors are therefore set to operate continuously for some 30 seconds after they are once started, which time is enough to deliver the carrier at the other end with enough reserve to prevent the carrier becoming stalled in the line due to the motor shutting down too early.



The Motor-Driven Blower with Time Limit Mechanism.

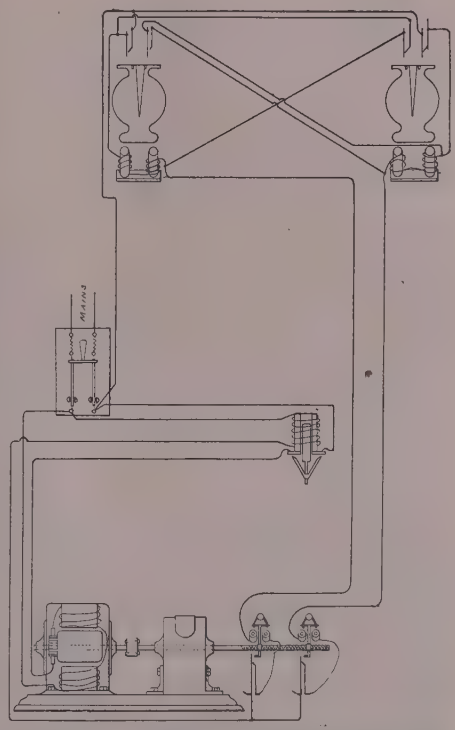
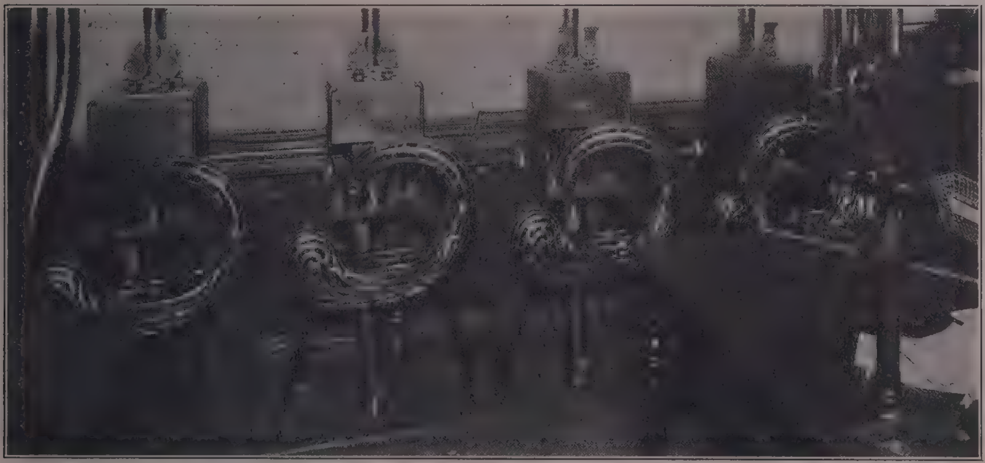


Diagram of Motor Control Circuits.



The Pneumatic Tube Station at the Cotton Exchange.

The motor-control mechanism is one of the most interesting features of the new equipment, consisting essentially of a motor-starting solenoid and two time-limit relays, the purpose of which is to shut off the motor after it has operated a predetermined number of revolutions. This control equipment is mounted on a stand which is incorporated with the framework supporting the motor and blower. It consists of a small slate switchboard with main switch and fuses conveniently mounted with the motor-starting solenoid, which is of a two-contact solenoid-lift type. The time limit mechanism is at the base and is in duplicate, each unit consisting of a pair of double-pole electromagnets which are arranged to throw, when magnetized, a traveling nut against a lead screw which revolves whenever the motor is in operation. This traveling nut has an insulated finger which, on traveling to a predetermined height due to the setting, breaks the circuit by which the motor is kept in operation.

The lead screw, of which there is one for either magnet and traveling-nut mechanism, is driven from the motor shaft below the board by spiral gearing, which has a ratio of about 10 to 1, causing the lead screw to make one turn to ten of the motor shaft. The traveling nut is held normally away from the lead screw by a spring, but is so pivoted that when its electromagnet is energized it will be held firmly against the lead screw and thus caused to rise vertically within a framework to which the electromagnet armature is attached. Both traveling nuts have insulated fingers projecting inwards so that either one will, when raised to a certain height, separate a pair of spring contacts and break the motor-control circuit, thus shutting the motor down. This interruption of the motor-control circuit also at the same time de-energizes the time limit electromagnets, releasing the traveling nut, which drops back to its normal position at the bottom, and also de-energizes the magnets that hold the air-tight door of the sending head closed, thus allowing it to open.

An interesting feature of this system is that carriers may be despatched in a tube from a sending station one after another continuously and with any desired degree of rapidity without hampering the operation of the system, in contradistinction to the necessity of waiting until a carrier has been transmitted to the other end and delivered from the tube before inserting another. This is made possible by the duplication of inserting doors and tube valves in the sending boxes, and of the time-limit mechanisms upon the blower outfit control boards. The arrangement of operating circuits of the electric door locks, motor-control and time-limit mechanisms is such that when a carrier is despatched through one of the air-tight sending doors, that door only is locked and one of the time-limit mechanisms only is set into operation, the escape of air pressure through the other sending door, which is unlocked, being prevented by a hinged flapper valve in the Siamese or Y-connection beneath the inserting tubes. This flapper valve is a two-faced swinging valve, so hung that the insertion of a carrier through one sending tube throws it to close the other sending valve tube, and vice versa. The continuance of air pressure through either sending valve tube after a carrier has been despatched through it thereafter maintains this flapper valve in a position closing the other valve tube until the carrier issues at the opposite end, when it drops to a neutral position. If in the meantime, however, a tube be inserted in the other sending door which remains unlocked and open, the closing of that door over a carrier operates through a combination of electric connections to both throw the time-limit mechanism formerly in operation out of service and unlock the previously locked sending door, and at the same time admits air pressure from the blower behind the newly inserted carrier. This carrier starts immediately, throwing the flapper valve to its opposite position to prevent escape of air from the other inserting door; the carrier thence follows the formerly inserted tube, both of which continue without regard to each other. This operation can be continued as rapidly as desired by the insertion of carriers in alternate sending doors. The closing of either sending door and despatch of a carrier acts automatically in every case to unlock the other door, which then springs open ready for use, and at the same time to release the traveling nut of the time element mechanism that was in motion and partially elevated, whereupon the other time limit is thrown into action.

The blower outfits used on this tube system require an unusually low speed motor and high speed blower in order to effect a satisfactory working combination. The motors used are 6-h.-p., series-wound, direct-current machines designed for operation upon 240-volt circuits. They run at 200 to 300 r.p.m., at which speed the blowers deliver 100 cu. ft. of air per minute normally at about 4 lb. pressure, which is necessary for the despatch of carriers at the required speed. An important feature of this blower is that the pressure builds up in proportion to the work being done, as much as 25 or 30 lb. being obtainable automatically, should a carrier stick in the tube at any point. This is one of the great advantages of a direct motor-blower system.

This interesting system was designed by Mr. Jno. T. Needham, district electrician, and Mr. J. F. Skirrow, associate electrical engineer of the Postal Telegraph Cable Co. The entire equipment was built by the Electro-Pneumatic Tube Co., Times Building, New York. The blowers were furnished by the Welch Machine Works, and the motors by the Electro-Dynamic Co., and the Connecticut Motor Co.

The New Soap Factory Building of Armour & Co. at Chicago.

A 120x310-ft. fireproof soap factory building, which has five stories and a basement for a length of 195 ft. and six stories and a basement for the remainder of its length, has recently been completed at the Chicago plant of Armour & Co. The building has independent brick side walls, a steel-cage framework and reinforced-concrete floors and roof. Owing to the great weight of the materials and the machinery equipment used in the process of soap manufacture, very heavy loads have to be carried in many parts of the building. A large part of the heaviest loads have to be placed in the upper stories of the building in order that the process of manufacture may be conducted in the most economical manner. Some of the machinery is operated at comparatively high speeds and most of it is on the upper floors. These conditions required not only a strongly-built building, but one which would overcome as fully as possible any tendency to vibrate.

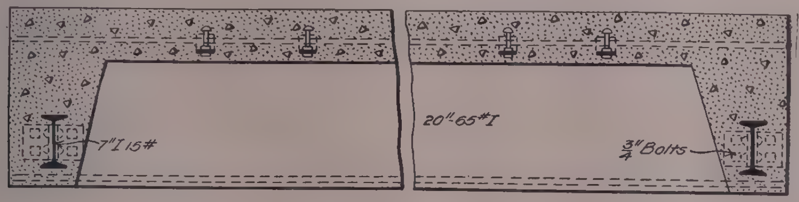
One End of Floor in Armour Soap Factory.

The greater part of the ingredients for the soap is delivered in tank cars on a railroad switch track along one side of the building. These ingredients generally have to be liquefied by heat applied through steam coils in the cars. The liquefied contents of each car are discharged by gravity into a large receiving tank on a platform scale in one end of the basement, the floor of the latter being 5 ft. below the switch track. The tank on the scale delivers to any one of thirty-six circular boiler-plate tanks, 6 ft. in diameter and 32 ft. long, in the other end of the basement. These tanks each have the same capacity as a tank car and are fitted with steam coils. The soap stock is stored in them until needed, when the contents of each tank can be liquefied and drawn off independently. The usual method in the manufacture of soap is to store the stock in one large tank which has to be heated at considerable expense whenever any amount of its contents are required.

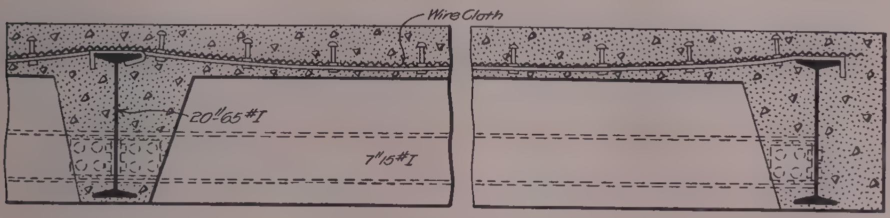
The soap stock is prepared in 22 boiling kettles in the six-story end of the building over the platform scale in the basement. The stock is lifted by compressed air from the storage tanks in the basement to the kettles through force mains, the total lift being about 68 ft. These kettles are made of heavy boiler-plate steel and have a capacity of 60,000 to 350,000 lb. of stock. The tops of all of them are open and are about at the same level in the fifth story of the building. The kettles are from 10 to 15 ft. in diameter. The largest ones extend down to, and are carried by, the frame of the third floor, while the others reach intermediate distances between that level and the fifth floor line. They are all heated by steam coils, the soap stock being kept at a boiling temperature for two weeks. The kettles are then allowed to cool for about four days before the soap is drawn out.

Laundry and toilet soap are both made in the same building. The manufacture of laundry soap is simple as compared with the methods required to produce the toilet soap, which has to pass through several intricate processes before it is prepared. The portion of the stock to be used for laundry soap is drawn from a kettle into tight steel cars, about 14 in. wide by 52 in. long and 54 in. high, which are on four-wheeled trucks. These cars each hold about 1,250 lb. of soap, their contents resembling in shape a steel ingot. These blocks are mechanically cut into standard size bars and the bars loaded on frames on trucks. These trucks run on grooved rails laid in the concrete floor. The soap on the frames on the trucks is placed in a drying room to season. This room occupies the middle section of the third floor of the building. It has hollow tile sidewalls built between the concrete-covered steel columns of the building, the floors above and below forming its ceiling and floor. It is heated by steam coils. Mechanical draft is provided by three 120-in. exhausters built by the New York Blower Co; these are on the same floor and are direct-connected to electric motors.

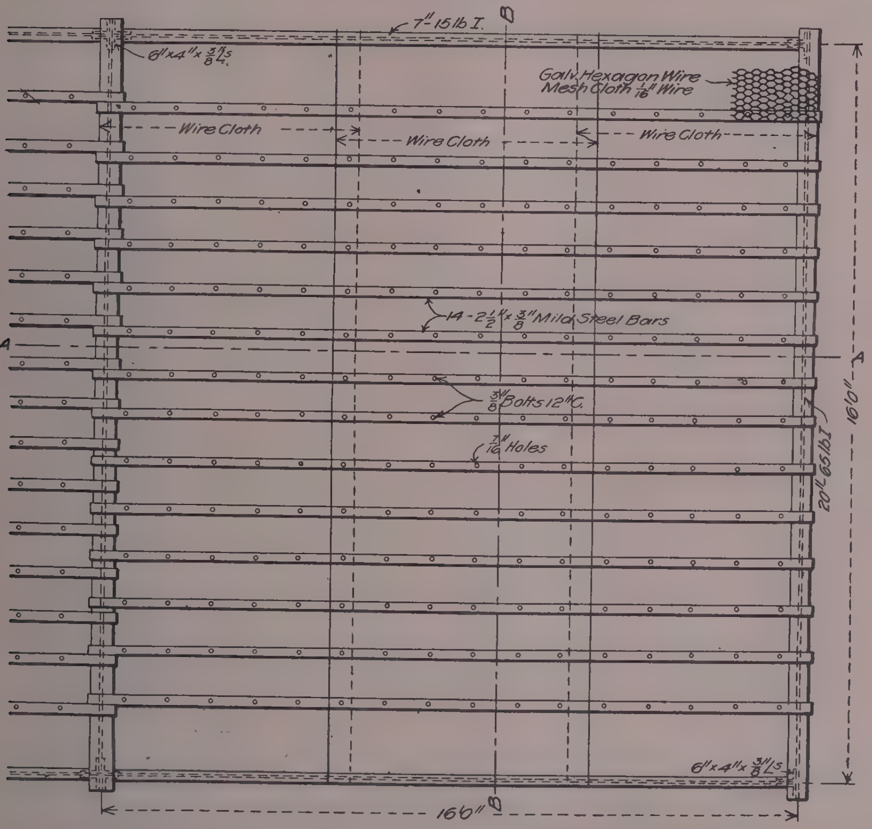
The toilet soap stock is passed directly to patented soap machines on the fifth floor. These machines produce the same results on the soap stock in 30 minutes that could formerly be secured only in three to five weeks. Each machine consists essentially of five vertical rows of rollers, about 10 ft. apart, with a series of horizontal wire-screen belt conveyors, one above the other, between these vertical rows of rollers. The rollers are in sets in each vertical row. The soap stock is subjected to a very heavy pressure by each set of rollers and then passed to a set at the same level in the other row on one of the belts. The whole machine is housed and the hôusing heated, so that the free water is reduced to a minimum, the stock being delivered from the machine in chips resembling those from a wood-planing machine. These chips are treated according to the quality of soap to be produced. They are then shoveled into the hopper of a compressing machine, which subjects them to a pressure of 300 lb. to the square inch and produces a continuous bar of soap with about the same cross-section as the completed product. From this machine the soap is passed through heavy presses and is then ready for packing. The packing boxes are all delivered from the ground to the fifth story of the building by an inclined chain-belt conveyer, which delivers to a gravity roller conveyor leading to all parts of the building. The packages are carried down from floor to floor by gravity on this roller conveyor, conveyor chains driven by small motors giving additional impetus when necessary.



CROSS SECTION B-B



LONGITUDINAL SECTION A-A



Reinforced Concrete Floor System for Armour Soap Factory.

The entire machinery equipment of the building is electrically driven. Electric power is supplied from a central station included in the manufacturing plant of Armour & Co. The boiler plant of this station also supplies live steam for the various heating processes. The electric motors of ½ to 2-h.-p. capacity are single-phase induction machines and are plugged into the electric lighting circuits. The larger motors have capacities up to 200 h.-p. each and are 500-volt continuous-current machines. The motors are direct-connected to the machines they drive, except where the dust from the machine is great enough to interfere with the operation of the motor, when the latter is belt-connected.

The building is divided into three sections by transverse brick firewalls. The electric wiring for each section is on a separate circuit which starts in a switch house outside of the building. The wires are all in pipe conduits laid in the concrete of the floors. The building is provided with two electrically-driven freight elevators. These elevators are in brick shafts, separate from the interior of the building, there being one elevator in each end section.

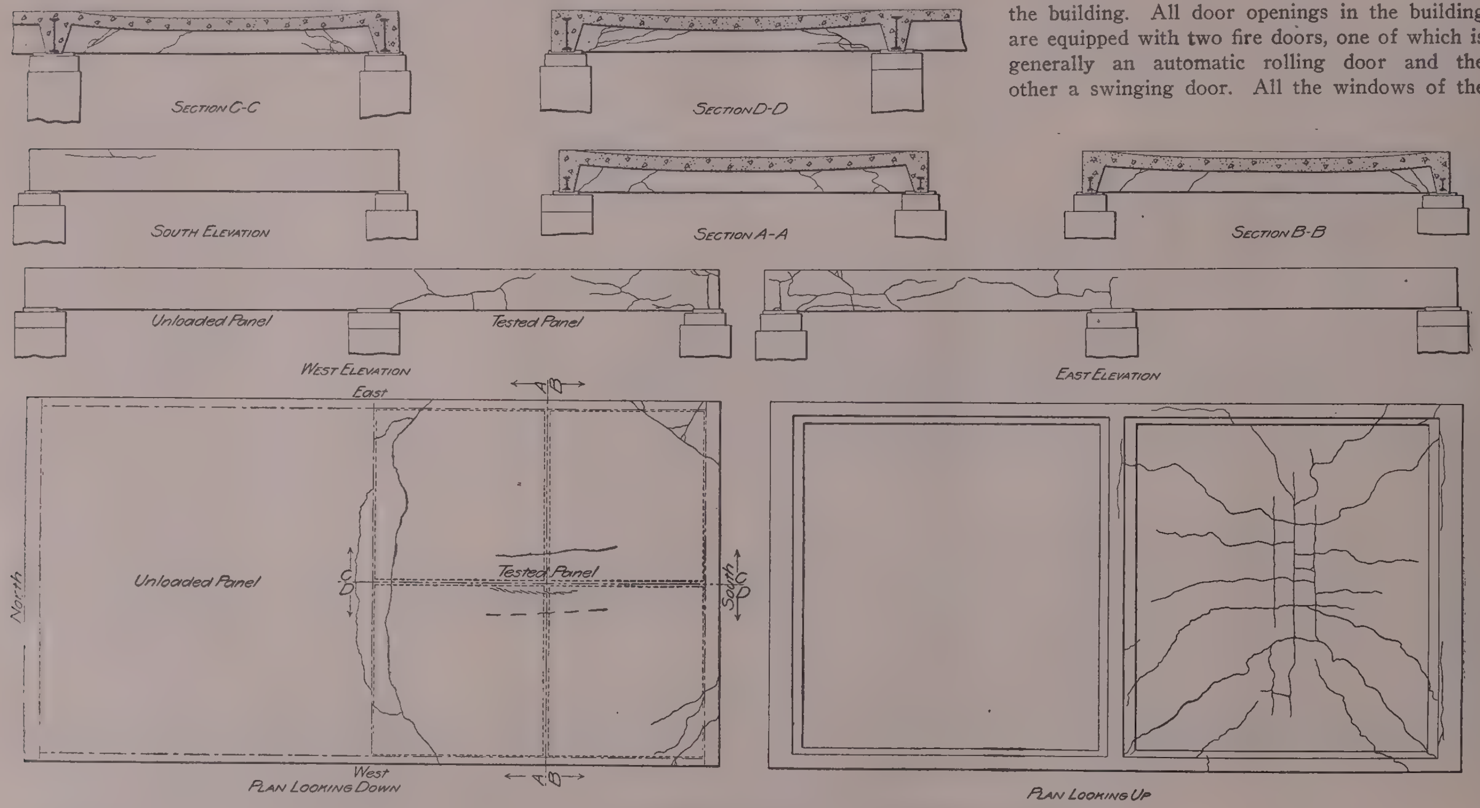
The very heavy loads of soap stock in the boiling kettles are particularly difficult to carry. The consistency of this stock is such as to cause layers of air to form in it toward the bottom of the kettle when the latter is heated, resulting in the whole mass in the kettle being raised from several inches to a foot quite frequently when the kettle is boiling. When these layers of air break through to the surface the boiling mass above them in the kettle drops back into place.

The kettles and the heavier machinery in the entire building are carried directly by the steel framing. A large portion of the loads, however, are carried by the concrete floors. The first floor is designed to carry a live load of 600 lb. per square foot; the other five floors carry 400 lb. and the roof 150 lb. The regular floor panels are 16 x 17-ft. in plan, the columns of the steel frame of the building being 17 ft. apart on centers across the building and 16 ft. apart on centers in the other direction. Between the rows of columns, which are 17 ft. apart, the floor framing consists of a 20-in. I-beam girder at each transverse row of columns, with 7-in. 15-lb. I-beams tying the longitudinal rows of columns together. The typical columns of the steel work have no unusual features. The boiling kettles are each carried by a steel frame and the four columns at the corners of a floor panel. The bottoms of the kettles being three to five floors above the footings of the columns, the latter had to be built to carry the heavy loads at considerable heights.

The details of a typical floor panel designed to carry a live load of 400 lb. per square foot are shown in one of the accompanying illustrations. The panel is reinforced according to a system devised by the R. S. Blome Co., of Chicago. The concrete slab is 7 in. thick and consists of 1-¼ parts Portland cement, 3 parts sand and 5 parts crushed limestone, measured in bulk. The reinforcement of each slab consists of fourteen ⅜ x 2½-in. tension bars between the 20-in. I-beam girders. The top flanges of those girders are 4 in. below the top of the concrete slab. The reinforcing bars of each panel are turned down square at the ends and hook over the flanges of 20-in. I-beams. They sag down toward the transverse center line of the slab, at which point they are 1 in. above the bottom surface of the slab. These bars have holes punched in them about 12 in. apart. In each of these holes is a ⅜-in. bolt, which extends 2½ in. above the bar. These bolts are fastened to the bar with a nut above and below the hole in the latter. Galvanized wire cloth, made of 1/16-in. wire and with 2½-in. hexagonal meshes, is placed over the reinforcing bars in strips between the tie beams, the strips overlapping 3 in. The floor panels which are designed to carry 600 lb. per square foot are reinforced according to the same method, the reinforcing bars being spaced closer.

A floor panel designed to carry 400 lb. per square foot and one designed to carry 600 lb. per square foot were built up together, with one 20-in. I-beam girder common to both panels, and tested prior to the erection of the building. The ends of the three 20-in. I-beam girders of the two panels were carried by dimension stone caps on square brick piers built up on the ground. These panels were built Nov. 3, 1904, with the intention of testing them the following spring. Later developments compelled an earlier test, so a shed was built over the slabs and a fire maintained in this shed for two weeks, beginning about the middle of January, prior to starting the test. Loading of the panel designed to carry 400 lb. per square foot was started Jan. 31, box tin, pig lead and pig solder being used in loading. The load was placed over the entire panel from center to center of the I-beam girder and ties, with the exception of a space about 3 in. wide on the transverse and longitudinal center lines, which spaces were left free in order to prevent arching of the load as the concrete slab became deflected. Three extensometers were used in measuring the deflection of the panel as the load was applied. One of these was placed under the center of the panel, one under the the 20-in. I-beam on the end distant from the unloaded slab, and the other under one of the 7-in. tie beams along one side of panel.

The loading of the panel was increased as rapidly as the material could be secured. When the load for which the panel was designed, 400 lb. per square foot, had been placed on the panel, the deflection at the center of the latter and at the center of the 20-in. I-beam was 1/16 in., with no deflection under the 8-in. tie beam and no cracks in the panel slab. The deflections at the center of the panel gradually increased with the loading until it reached 15/16 in. at a load of 987 lb. per square foot, the deflection at the center of the 20-in. I-beam girder being ¼ in. at the same time. At this loading, the first cracks were observed along the girder at the end of the panel distant from the unloaded panel. These cracks were apparently caused by the beam turning and bulging out, owing to lack of lateral support, so timber shores were wedged against the side of the beam to prevent further turning. The extensometer under that beam was thus put out of service and shortly afterward the extensometer under the tie beam was disturbed, so that the deflections at these two points were subsequently taken with an engineer's level.



Cracks in Test Panel of Floor System Used in the Armour Soap Factory.

The first crack in the top of the panel appeared at the corner lettered X in the accompanying plan of the panel, when the load reached 1,083 lb. per square foot. At 1,100 lb. per square foot cracks had appeared at all four corners of the panel and at the center of the tie beam the deflection at the center of the panel being 1¼ in. The loading was then continued until the ultimate load reached 1,630 lb. per square foot. Under this loading the final total deflection at the center of the panel was 5 1/16 in. At 1,275 lb. per square foot, a crack was observed curving into the unloaded panel and apparently making a continuous crack with the crack across the adjacent corners of the loaded panel. The opposite end of the unloaded panel was later found to have been lifted clear of the brick piers under the two corners on that end. At 1,460 lb. per square foot, the deflection at the center became 3⅞ in. On leaving this loading over night the deflection at that point increased to 4 7-16 in. The cracks at the corners had by this time become deeper and wider, and deep cracks extended along the tie beams, diagonally down and toward the center of the panel. Shear cracks had also appeared near the supports of all beams and under the panel at the corners in the angles between the panel and the beams. The concrete on the outer side of the 20-in. I-beam on the side of the panel distant from the unloaded panel was also cracked almost entirely away from the beam, due evidently to the turning of the latter which had no support from an adjoining slab. The under side of the panel had narrow cracks in both directions, crossing at right angles, with a few minor diagonal cracks.

After the ultimate load of 1,630 lb. per square foot had been on the panel for three days and the deflection at the center of the panel had reached about 6 in., the load was removed, the unloading extending over three days. The deflection at the center of the panel was reduced to 4½ in., when the panel was unloaded. The permanent deflection at the center of the top of the panel was 4 in., while the deflection at the center of the tie beams and girder which did not buckle was ⅜ in. Open tension cracks remained across the corners and along the sides parallel to the beams, except along the 20-in. I-beam which had turned and broken away from the concrete. The cracks at the corners were wider and deeper than any of the others. Compression cracks were visible near the center and scattered over most of the panel. These cracks, or nearly all of them ran parallel to the 7-in. tie beam, but there were no cracks in the top of the slab on the center line parallel to the 20-in. I-beams. The location of the various cracks is shown in the accompanying illustrations.

The impossibility of loading the panel as fully as a similar panel in a continuous floor could be loaded is very evident from the manner in which the cracks appeared and the beams were turned and buckled. The four brick piers were all badly cracked and the cap stones on them cracked through. This is considered to have been due to the uneven pressure brought on them by most of the weight coming on the inner corner of the piers, for if the load on the panel had been evenly distributed over the piers the bearing on the latter would have been less than the safe bearing value of ordinary brickwork. The test was, therefore, considered to demonstrate that floors of the building built according to the design of the panel tested would carry the required loading with a large factor of safety.

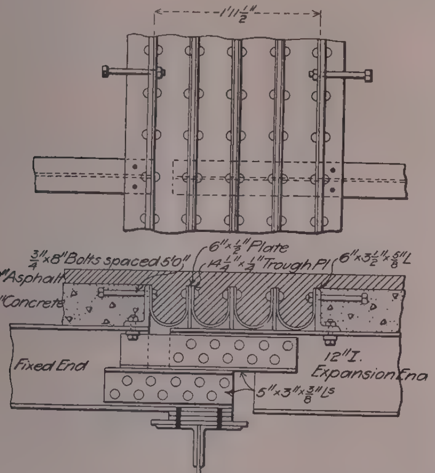
The steel columns of the building are encased in concrete for fire protection. The stairs throughout the building are of reinforced concrete and are in fireproof shafts, separate from the elevator shafts and from the main part of the building. All door openings in the building are equipped with two fire doors, one of which is generally an automatic rolling door and the other a swinging door. All the windows of the building have copper frames and are glazed with wire glass. A standpipe is built in each stairway shaft and several standpipes are placed around the exterior of the building. These standpipes are all under 100 lb. pressure from an independent water supply system, which is furnished with pressure from the central power station of the plant.

The building was designed and erected under the direction of Mr. Robert C. Clark, architect and superintendent of construction for Armour & Co. The reinforced concrete work is designed according to the system controlled by the R. S. Blome Co., of Chicago, and was carried out by that company.

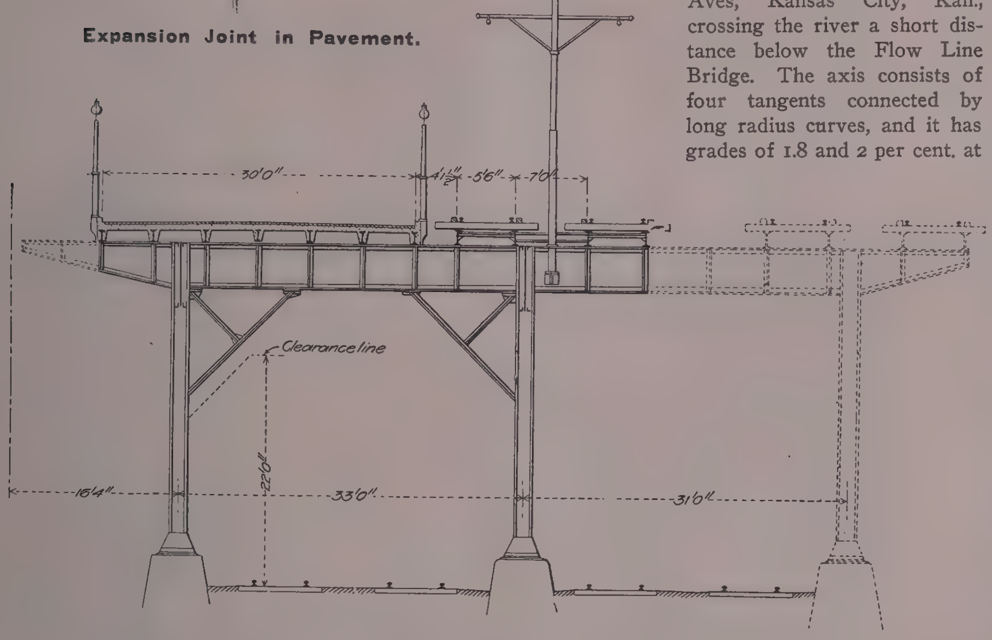
Rapid Steelwork Erection was recently done by John Monks & Sons on the Ward Line pier in New York. The structure is 527½ ft. long, 76 ft. wide and has a 74½-ft. portion two stories high. There are 27 transverse bents with roof trusses. Sixteen calendar days, including 5 days lost time, was enough for the erection.

The Sixth Street Viaduct at Kansas City.

The steel highway viaduct which is now under construction at an expense of about $2,500,000 to connect Kansas City, Mo., and Kansas City, Kan., was described in a thesis prepared last summer by Mr. N. Everett Waddell, an undergraduate student at the Rensselaer Polytechnic Institute. It considers at length the conditions at the site, the necessity for the viaduct, the history of its inception and promotion, the analysis of its probable cost and service, the methods of financing it, and briefly describes the characteristic features of design. Space is not here available for these details, but the principal features of the work are here summarized from this thesis and additional information furnished by the author.



Expansion Joint in Pavement.



Cross Sections of Present Viaduct and Proposed Extension.

Kansas City, Mo., is separated from Kansas City, Kan., by the Kaw River and its bottom land on which portions of both cities are built. This bottom land is low and flat, with an average width of a little more than a mile between the bluffs on which the residence and commercial parts of both cities are chiefly built. In May, 1903, the greatest recorded flood inundated the entire bottom, and carried away nearly all the bridges, as described in these columns at that time.

In order to guard against future losses due to interrupted communication between the cities, the scheme was conceived by Mr. W. J. Knepp, of Kansas City, Mo., of building a long toll viaduct from bluff to bluff across the river and valley. It was demonstrated by careful observations and old records that a gross revenue of $1,000 a day might be relied on from tolls as soon as the structure was completed, and that this would probably increase in at least equal proportions with the growth of the city, which is now about 10 per cent. annually. It was estimated that although this viaduct competes with free bridges, it will be used by nearly 10,000 teams a day on account of the easier grades, more direct communication and especially because of the avoidance of grade crossings which intersect a large number of railroad tracks and yards on the low ground and cause great delay to trucking.

A contract was made with the Metropolitan Street Railway Co. for a double-track line over the structure and for a payment of 1 cent each for every passenger carried. In August, 1904, charters were obtained from both cities authorizing the construction of the viaduct and approaches, with certain restrictions of width and clearance heights, and the privilege of operating on it a double-track railway using steam, electricity or other motive power. Bonds to the amount of $3,000,000 were issued, plans and estimates were prepared, and the work is now being conducted under the direction of Messrs. Waddell & Hedrick, the consulting engineers, who were also the principal promoters of the enterprise. The contracts for the substructure and superstructure were awarded and work was commenced in August, 1905.

The main viaduct has a total length of 1.6 miles, including 340 ft. of earth-fill approach, and extends from Bluff and Sixth Sts., Kansas City, Mo., to Fourth and Minnesota Aves, Kansas City, Kan., crossing the river a short distance below the Flow Line Bridge. The axis consists of four tangents connected by long radius curves, and it has grades of 1.8 and 2 per cent. at the ends, connected by a long and nearly level tangent in the center. The main structure has a roadway 38 ft. wide for about 1,800 ft. from the Missouri end to the Mulberry St. approach, which intersects it at right angles. The remainder of the structure has a width of 30 ft. and is provided with two more intersecting approaches, each 20 ft. wide, making angles of nearly 90 deg. with its axis, besides the main entrance at the end of the viaduct. There is also on one side of the roadway a 20-ft. platform carrying two street railway tracks from end to end of the main structure. There is for the main structure, a minimum vertical clearance of 24 ft. over all streets, alleys, and intersecting car tracks and these crossings are made with single-span girders supported back of the property lines. The height of the roadway above the surface of the ground is quite uniform and attains a maximum of 42 ft. near the Missouri end and nearly 100 ft. above the low-water level of the Kaw River.

The river crossing is made with two 300-ft. double intersection riveted deck spans. The depth of these trusses is necessarily limited to 37½ ft. in order to provide the required clearance above high water. There is also a 147-ft. span skewed 54 ft. in 33 ft. over the Kansas City suburban belt lines. This span has riveted deck trusses of the triangular type 15½ ft. deep on centers. The remainder of the main structure, except the embankment approach, is made with plate girder spans riveted to steel columns on concrete pedestals.

There is one span of 107.25 ft., one of 87.583 ft., one of 76 ft., and several spans between this and 45 ft. Most of the spans, however, are 45 ft. in length, and are arranged in general groups of seven supported on single transverse bents or columns. The groups are separated by 30-ft. spans supported on four columns braced longitudinally to give anchorage and rigidity to the structure. At each tower there is an expansion bearing for the west end of the span, the metal being proportioned to take the temperature extensions for 345 lin. ft. of the structure.

The roadway portions of the viaduct are designed for a uniform live load of 100 lb. per square foot of floor surface or for a 30-ton road roller. The street railway part is designed for the heaviest modern street railway loading and for stresses due to brakeing trains. All parts of the structure are proportioned for a wind load of 30 lb. per square foot over the entire vertical portion of the structure and its maximum live load of cars and vehicles. The superstructure is made with reamed medium steel.

The Kaw River bridge has an estimated weight of 2,800,000 lb., the remainder of the main viaduct 18,000,000 lb., which, with the weights of the three approaches, makes a total of 26,000,000 lb. The contract provided for the completion of the work in eleven months after its award, in case the superstructure was not delayed by the substructure or by waiting for the completion of the detail plans, provision being made for proportional extension of the contract time if such delays were incurred.

The substructure is of concrete. The three piers for the river spans have foundations carried to rock at a maximum depth of 53 ft. below low water in wooden pneumatic caissons. The column and viaduct posts have separate concrete pedestals built in open excavation and carried down a few feet below the surface of the ground; some of them are seated on the earth and some are carried on clusters of twelve or more piles. The contract for the entire substructure was awarded to Mr. James F. Halpin, who sublet the pneumatic piers to Messrs. Kahmann & McMurray, both of Kansas City.

The caissons are of ordinary construction, 18 ft. wide and 53 ft. long over all, with a working chamber about 8 ft. high above the cutting edge. The walls have triple courses of 12 x 12-in. timber and the deck has six crossed courses of 12 x 12-in. timber. The caisson is sheathed inside with 3-in. planks and is braced just above the cutting edge by four transverse struts with two 1½-in. tension rods parallel to each. The cutting edge is a 6 x 6-in. angle reinforced by a vertical plate, and a bent horizontal plate, the latter covering the bevelled inner face of the lower wall timber. The caisson is sheathed outside with vertical boards and above its roof there is a permanent timber cofferdam 51 ft. high with walls of 12 x 12-in. timber.

The concrete pier above the cofferdam is 45½ ft. long over all and 9 ft. wide on the coping, with semi-circular ends. Both sides and ends of the pier are battered 1:24. All timber is of long leaf southern yellow pine, sized on all sides. Concrete is made 1:3:5 with Iola Portland cement. The top of the pier is made with 1:2:3 granitoid, composed of Portland cement, sand and ½-in. granite chips or Joplin flint. The concrete piles under the viaduct piers were constructed by the Foundation Co., of New York.

The contract for the entire superstructure was awarded to the Riter-Conley Manufacturing Co., Pittsburg. The longitudinal viaduct girders have generally a uniform depth of 6 ft., and are web-connected at their ends to the flanges of vertical columns having open H-shaped rectangular cross-sections, made of two built channels and a web. The columns are all arranged 33 ft. apart transversely in bents which, as before stated, are spaced from 30 to 90 ft. apart, the greater number of them being single bents 45 ft. apart. Part of the roadway is carried by a cantilever bracket extension which projects about 7 ft. beyond the columns of one side of the viaduct and is intended to receive a future extension of about 7 ft. to carry a sidewalk.

One of the street car tracks is carried between the viaduct posts and the other is carried on an 11-ft. cantilever extension of the transverse girders. This extension is designed to be connected if necessary at some future time with another section of the girder which will increase its length to about 30 ft. and will be supported at the opposite end by a new column which, with its cantilever bracket, will afford support for two additional railroad tracks. The same construction is adopted for that part of the viaduct which has a 38-ft. highway, except that in this case the present cantilever bracket is longer and no extension for it is contemplated for a future sidewalk.

The tower panels are X-braced longitudinally. The truss spans are provided with the usual top and bottom end sway-brace system of riveted members, and all of the spans have zigzag lateral bracing of 4 x 4-in. angles connecting the stringers in the panels between the floorbeams, except at the middle of the tower spans. This bracing is in panel lengths of 7½ ft., separated by transverse 10-in. channels connecting the stringers. The ends of all longitudinal girders and floorbeams are faced, and holes for their field rivets are reamed to cast-iron templates.

An interesting feature of the design is the provision made at every tower for the expansion movement in 345 ft. of the continuous superstructure adjacent. The fixed stringer has the upper corner of the web notched and a pair of angles riveted to the web so as to form, with their horizontal top flanges, a seat for reversed bearing angles riveted to the web of the drop end of the expansion stringer. These angles project beyond the end of the stringer to form jaws sliding back and forth over the upper part of the web of the fixed stringer.

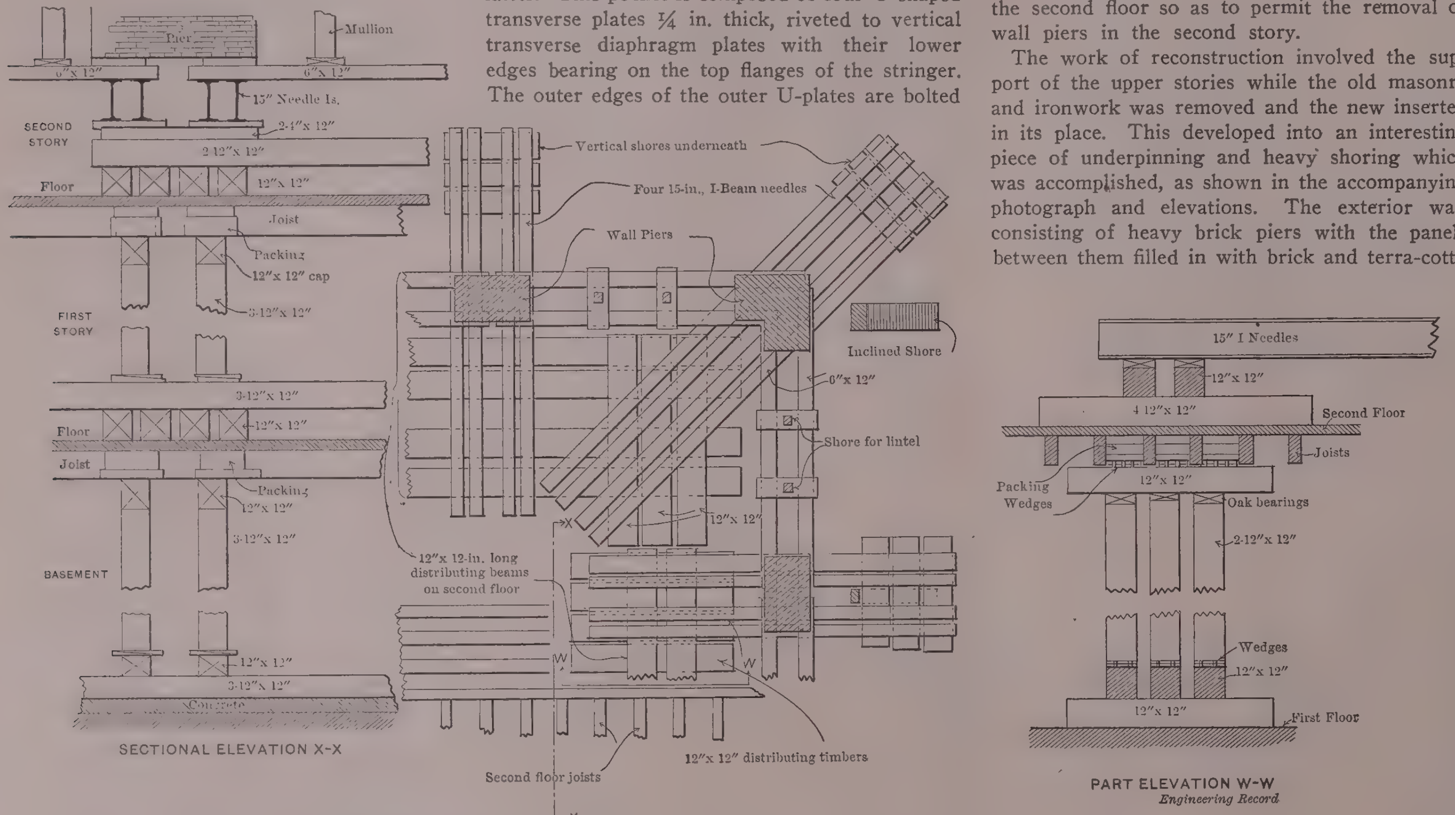
The top flange of the sliding stringer supports at the end an adjustable pocket which receives the asphalt road surface and is intended to move back and forth without causing the rupture of the latter. This pocket is composed of four U-shaped transverse plates ¼ in. thick, riveted to vertical transverse diaphragm plates with their lower edges bearing on the top flanges of the stringer. The outer edges of the outer U-plates are bolted to transverse angles secured to the top flanges of the fixed and sliding stringer respectively, thus connecting the stationary and movable parts of the platform with a flexible apron intended to open and close like an accordion. The surface of the asphalt will, of course, rise and fall with this motion, but it is believed that it will be so soft as to flow back and forth and be continually packed down level by the traffic.

The roadway is carried on longitudinal steel I-beams 5 ft. apart, enclosed on both sides by extensions integral with the 6-in. concrete slabs forming the roadway platform. These slabs are made with 1:3:5 concrete composed of Iola Portland cement and ¾-in. stone, and reinforced by transverse ½-in. corrugated steel bars 6 in. apart in the lower portion of the slab and 12 in. apart in the upper portion. The concrete casing of the stringer is supported and bonded by expanded metal furring. The concrete is covered with the standard asphalt pavement used in Kansas City. The roadway stringers are neither painted nor oiled, it being considered that the concrete protection is more efficacious when applied to the naked metal. The substructure is completed, a large proportion of the steel work has been fabricated at the bridge shops and its erection has been commenced.

Underpinning the Criterion Hotel, New York.

The seven-story Criterion Hotel at Broadway and 41st St., New York, has wooden floors supported by an interior longitudinal row of columns and by the outer brick walls laid in lime mortar. Recently improvements have been made and the building has been modified so as to adapt it for commercial purposes. The principal changes included the substitution of steel columns for brick piers at the Broadway corner of the building, the replacement of an old box girder which carried the six upper stories on the Broadway front by a new girder composed of three lines of 24-in. I-beams seated on new columns, the insertion of smaller wall girder I-beams on the 41st St. front, the support of interior partitions on new I-beam girders at the second floor level and the removal of a girder in the rear wall from the first to the second floor so as to permit the removal of wall piers in the second story.

The work of reconstruction involved the support of the upper stories while the old masonry and ironwork was removed and the new inserted in its place. This developed into an interesting piece of underpinning and heavy shoring which was accomplished, as shown in the accompanying photograph and elevations. The exterior wall consisting of heavy brick piers with the panels between them filled in with brick and terra-cotta work and double windows, as shown in the photograph. The principal piers affected by the alterations were first braced by inclined shores having their square upper ends gained into the brickwork and bearing on beveled cap pieces set in cement mortar to give 10x12-in. bearings. The lower ends were seated with double pairs of wedges on sills laid on the sidewalk. In some cases the shores were continuous through the sidewalk and extended in one piece to the bottom of the sidewalk vault.



SECTIONAL ELEVATION X-X

PART ELEVATION W-W
Engineering Record

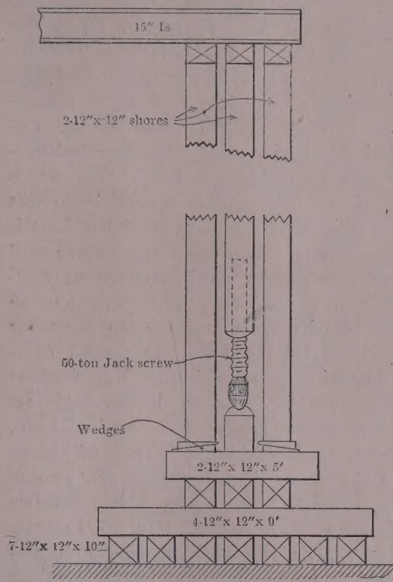
Needle Beams and Two-Story Shores at Corner Pier, Criterion Hotel.

After these shores were securely adjusted, slots were cut in the sides of the piers and in them pairs of 15-in. horizontal I-beams were placed just above the second-floor level to serve as needle beams. In some cases three instead of two I-beams were used in each set, thus giving either four or five needles at every pier. The outer ends of each pair of needles were supported by three 12x12-in. vertical shores with wedges and cross-pieces, as indicated in the detail. The lower ends of these shores rested in some cases on sills on the sidewalk which was shored up by corresponding verticals in the vault below. In other cases the shores were continuous through the sidewalk to the vault floor. In all cases the bottoms of the shores were provided with jack-screws and pair of wedges for adjustment and with a solid cribwork of timber to distribute the pressure on the vault floor.

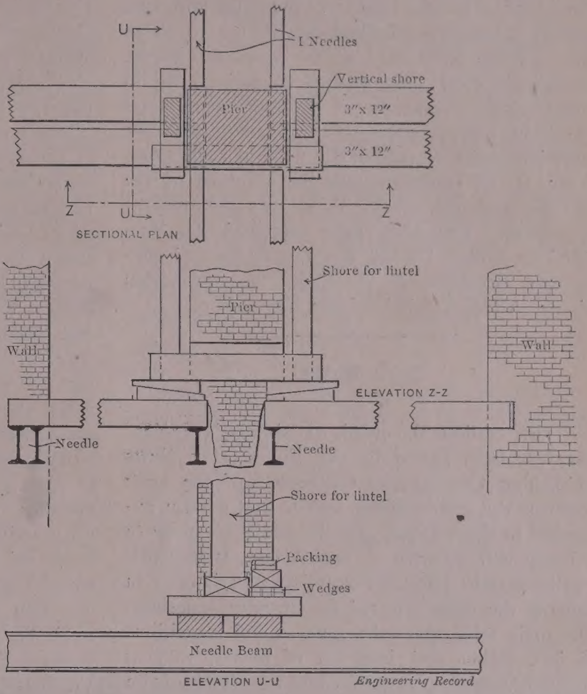
The inner ends of the needles were seated on 12x12-in. distributing beams laid on the second floor parallel to the walls. In some cases a second tier of beams at right angles to the first was interposed between them and the floor, so as always to distribute the load over a number of the floor-joists. Underneath the floor the spaces between the joists were packed solid with blocking resting on the upper surface of 12x6-in. timbers transverse to the joists and giving them direct support opposite the points of loading. These timbers were seated on the tops of pairs of 12x12-in. vertical shores reaching to the basement floor where they rested on three lines of 12x12-in. horizontal sills extending across the full width of the cellar parallel to the outer walls. Pairs of wedges were inserted between the feet of the shores and were adjusted for the shoring and needles.

The needle-beams were all set with an inclination downwards of about 1½ in. from the inner to the outer end. The center shore in each group of three under a pair of needles was always provided with a 50-ton hand-made jack-screw by which bearing was secured. Pairs of 3-in. hickory wedges 1½ in. thick and 16 in. long were put under the feet of the adjacent shores and driven up as fast as the jacks were operated, so as always to relieve the latter. In this way the ends of the needles were lifted up about level, taking the full weight of the wall, as was determined by sounding it. Each wall pier has an estimated load of about 50 tons and the jack screws were each operated by three men working on a 6-ft. bar. After the structure was thus supported, five old cast-iron columns were replaced by new steel columns, the box girder was replaced by the 24-in. I-beams, some 5-in. I-beams in the wall were replaced by new ones and the brick mullions in the center of the windows were removed and new ones were put in.

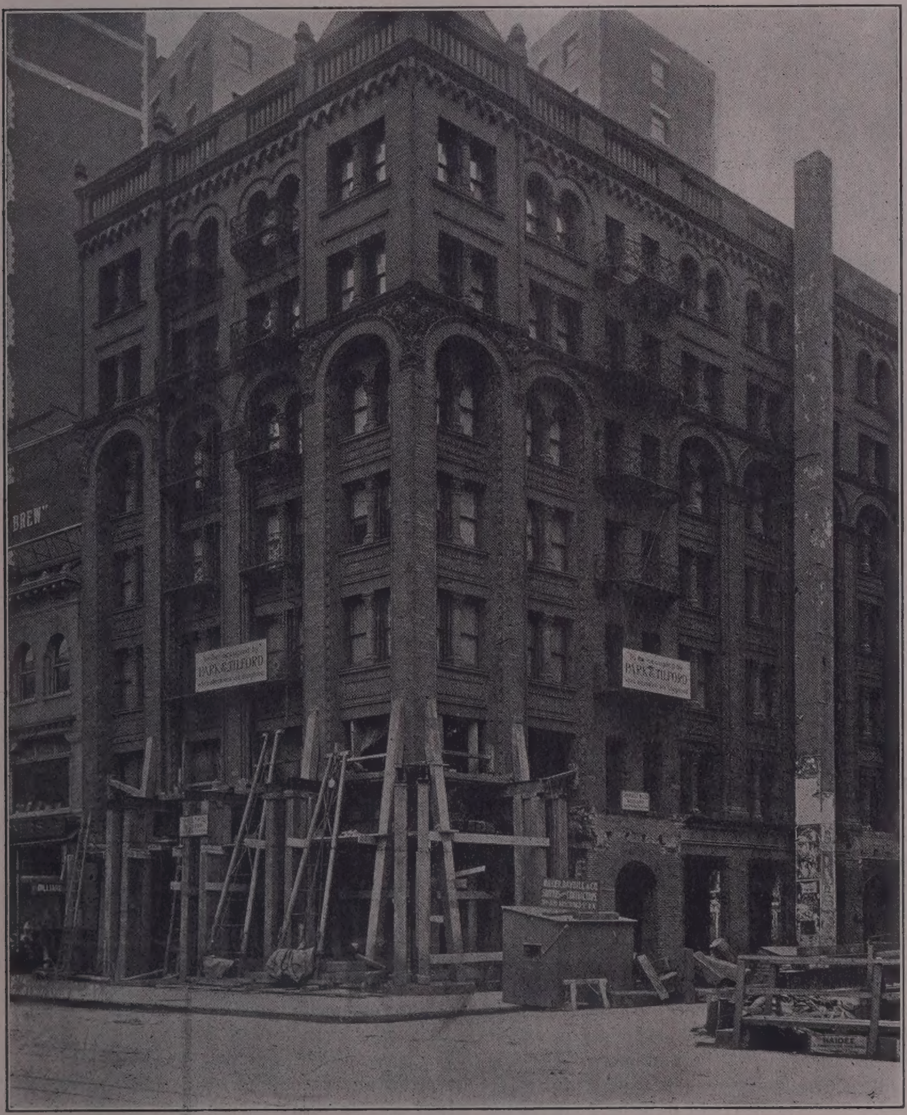
In the rear of the building holes were cut through transverse partitions about 13½ ft. apart and in them pairs of 15in. I-beams about 24 ft. long were set 6 ft. apart and supported on shores to carry the upper stories of the walls, while the lower stories were removed and replaced by steel columns and girders. The upper seven stories of the outer wall in the rear extension were carried on a box girder at the first-floor level, which was taken out and replaced at the second-floor level so as to allow the first-floor wall to be removed.



Foot of Shore under Main Wall.



Supports for Small Window Pier in Rear Wall.



Underpinning the Criterion Hotel, New York.

In order to do this, the wall, which contained one 24x30-in. and one 12x24-in. brick pier separating the window spaces, was needled above the second floor and supported on shores carried down to the cellar floor. As the piers were of small dimensions, special care was necessary to undercut them without injury. Slots were cut just above the second floor level in the sides of the piers between the windows, and in them were placed single 15-in. I-beams about 20 ft. long, supported in the usual manner by shores and wedges at both ends. The top flanges of the I-beams carried the ends of pairs of 3x12-in. planks laid flat, with their ends extending into the recesses and abutted against the masonry in the window piers. On these planks transverse timbers parallel to the needle beams afforded sufficient bearing for vertical shores set close to each side of the wall pier and supporting the spandrel beams over the windows.

As the masonry in the pier was not considered sufficiently supported by the bearings on the sides, an additional recess transverse to the first pair and parallel with the face of the wall, was cut above the needle beams on the inside of the wall, and in it was placed a transverse timber resting on the needle beams and, like the vertical shores, adjusted to bearing with pairs of wedges. By this arrangement the entire weight of the window framing and intervening piers was carried by three sets of needles and shores, as indicated in the diagram, thus allowing the old wall to be removed below and replaced by the old girder moved up one story above its original position.

Operations on the reconstruction and underpinning were commenced Nov. 1, 1905, by twelve men, who cut out the brickwork and set the shores for the repairs on the front walls, and was finished in about 60 days. It required about 10,000 ft. B. M. of 12x12-in. long-leaf yellow-pine timbers 25 ft. long for vertical shores and from 35 to 40 ft. long for the sills and ties, besides a quantity of blocking from 4 to 10 ft. long. There were used on the work ten 3½-in. hand-made steel jack screws 24 and 30 in. in length, with a capacity of 50 tons each, forty-one 15-in. steel I-beams 16 ft. long besides other materials and tools ordinarily used in such work.

Mr. R. N. Anderson was the architect of the building and Mr. C. T. Wills was the general contractor. The work here described was executed by Miller, Daybill & Co., shorers and contractors, Brooklyn, N. Y., under the supervision of Mr. Alfred Daybill, of the above firm.

Book Notes.

A new edition, the third, of "Smoley's Tables" has just been issued by the Engineering News Publishing Co. The extensive use of the book confirms the good opinion of the first edition expressed in these pages, and the additions made to it lately will increase its usefulness. It was primarily prepared for the solution of triangles in figuring the data required for structural designs. The main table gives the squares and logarithms of feet, inches and fractions of inches, varying by 1/32 in. from 0 to 50 ft., and by 1/16 in. from 50 to 100 ft. The squares and logarithms are arranged in parallel columns, not only because these figures are often required at the same time, but also because in some calculations only the squares and logarithms are used, while if the logarithm of the square is required it can be readily obtained by multiplying its corresponding logarithm by 2. The most common problem is to find the hypothenuse, bevel and logarithmic functions of the angles when the half-span and rise are given, and the arrangement of table simplifies the computations materially. Other tables give the angles and logarithmic functions corresponding to bevels given to a base of 12 in., the bevels increasing by 1/32 in.; the logarithms of numbers, the decimal equivalents of inches and fractions of an inch, and various constants often used by the steelwork designer.

An investigation of the "Underflow in Arkansas Valley" in western Kansas is described in Water Supply and Irrigation Paper 153, published by the U. S. Geological Survey. Prof. Charles S. Slichter, the author, mapped the ground-water level within 6 to 12 miles of the river channels and measured the flow of the water by his well-known electrical method. The measurements were made in private wells and a few sunk for the purpose. The underflow was found to have an average rate of 8 ft. in 24 hours, in the general direction of the valley. The water surface slopes to the east at the rate of 7½ ft. per mile and toward the river at the rate of 2 to 3 ft. The underflow has its origin in the rainfall on the sandhills south of the river and on the bottom lands and plains north of the river. The influence of the floods in the river on the ground-water level does not extend half a mile north or south of the channel. A heavy rain has more influence than a flood. It was found that on the sandy bottom lands 60 per cent. of an ordinary rain reaches the water plane as a permanent contribution. The amount of dissolved solids in the underflow grows less with the depth and with the distance from the river channel. Private pumping plants in the bottom lands will be profitable for irrigation, Prof. Slichter states, if the proper kind of power is used. He believes that suction-producer plants of 20 to 100 h.-p. will prove profitable, using Colorado hard coal or coke.

Report of the Electric Railway Test Commission to the President of the Louisiana Purchase Exposition J. G. White, chairman, George F. McCulloch, H. H. Vreeland, W. J. Wilgus, James H. McGraw, commissioners. New York, McGraw Publishing Co.; cloth, 8vo, 634 pages, $6.00.

The large amount of electric railway apparatus at the Louisiana Purchase Exposition offered an exceptional opportunity for obtaining valuable information equally useful to the maker and user of it. Accordingly President Francis, in consultation with Director Goldsborough of the Department of Electricity, appointed five commissioners to take the subject in hand. The manifest value of the information obtainable in this way led the Executive Committee of the American Street Railway Association to endorse and assist the commissioners' work, and manufacturers assisted it in various ways. In order that the work might be of maximum value the plans for it were outlined by the following special committees: Tests of City and Suburban Equipments; M. G. Starrett, D. F. Carver, W. S. Twining. Tests of Interurban Equipments, A. L. Drum, Charles Jones, C. A. Alderman. Tests of Heavy Traction Equipment, F. J. Sprague, B. J. Arnold, W. J. Wilgus, F. R. Slater. New Electric Railway Systems, B. J. Arnold, Paul M. Lincoln, W. B. Potter. The reports of these committees not only laid down the lines on which the tests should be conducted, but were admirable statements of existing conditions. These recommendations were turned over to an executive committee to carry out; this committee consisted of Prof. Goldsborough, chairman, and Profs. H. H. Norris, B. V. Swenson and H. T. Plumb, and was assisted by Messrs. A. H. Armstrong, Clarence Renshaw, W. S. Arnold and W. N. Smith as an advisory committee.

The tests were begun June 15, 1904, and completed March 22, 1905. It was found to be impracticable to follow all the original plans, sometimes because manufacturers were reluctant to have certain apparatus tested and sometimes because of lack of facilities for testing. The work accomplished, however, gives invaluable data to the railway operator, whether he is running a small city system or is investigating the substitution of electricity for steam on some branch or terminal.

The report gives the results of these tests in collated form, so that all the information on a subject is brought together in one place without reference to the time or manner in which it was obtained. Thus there are four chapters giving service tests of different cars, two chapters on acceleration tests of city and interurban cars, four chapters on brake tests, one on the tests of an industrial locomotive, two on alternating current losses in rails and track, and three on resistance tests. An appendix brings together in form for ready use the principal data of the tests and an excellent index makes it possible to consult the book easily.

The volume is unquestionably the most important contribution of late years to the literature of electric railway engineering. The broad plan of the investigations, the exceptional facilities for making the tests, and the skill of those who directed the work produced results pushing back in many directions the line of demarcation between the definitely known and the conjectural. This is not the place to state, even in outline, the specific data obtained; in fact only a careful investigation of the contents of the volume will afford any true conception of its importance. Such work could only be done by the cooperation of many people, and the opportunity for securing such cooperation comes so rarely that the good use made of it on this occasion is a fact for which all interested in electric traction should consider themselves fortunate.

Letters to the Editor.

The San Francisco Post-Office.

Sir: Your issue of May 12, which has just come to hand, contains an article by Prof. Soulé referring to the damage by earthquake to the San Francisco Post-Office, which, however, conveys an erroneous impression which should be corrected. The soft upper strata of the surrounding street and sidewalk slipped away from the building at Seventh and Mission Sts., from 1 ft. to 3½ ft., but the foundations are not defective, as stated, but are in excellent condition, as shown by the instruments and the lines run since the disaster. The accompanying photographs will show how true this is, and instead of any censure being placed upon the Office of the Supervising Architect and the Superintendent of Construction, Mr. J. W. Roberts, the greatest credit is due them.

It is the opinion of the army engineer and other experts who have carefully examined the situation, that the Post Office Building received a greater shock than many surrounding buildings or the demolished City Hall. The granite walls on every side of the Post-Office Building are not badly cracked from the third story under the roof to the foundations, as your correspondent avers. The exterior walls above the second story sill course show no cracks or signs of bulging. The granite work below the girders, supporting the second story sill course, shows the tremendous shock which was received by the building, breaking and snapping apart the heavy wrought-iron stirrups, anchors and ties, which may be plainly seen. So well braced was the construction, however, that the machinery and the four elevators were started as soon as water could be procured, and have been running ever since in perfect condition.

Not a crack is to be seen in the long third-story corridor ornamental plaster ceilings, or in the magnificent first-story marble mosaic ceilings of corridors, except at the entrance vestibules, where terra cotta was used. Much damage was done to the terra-cotta partitions by the earthquake and the subsequent dynamiting of adjacent buildings; this dynamiting blowing out oak panels from doors and shaking marble slabs loose, in a number of cases necessitating their temporary removal.

Respectfully, W. A. Newman.
Superintendent of Construction,
U. S. Public Buildings.
San Francisco, May 21.

Reinforced Concrete Columns.

Sir: The writer was much interested in the very pertinent editorial on the design of reinforced concrete buildings in the Record of May 19, and believes the position in regard to the shear in beams is very well taken. He is not clear as to the intention in regard to columns, and if not asking too great a favor, would be pleased to learn just the type of columns it was intended to suggest. He gathers that you intended a column made up of structural shapes, such as angles, channels or I-beams, latticed, and filled and surrounded with concrete.

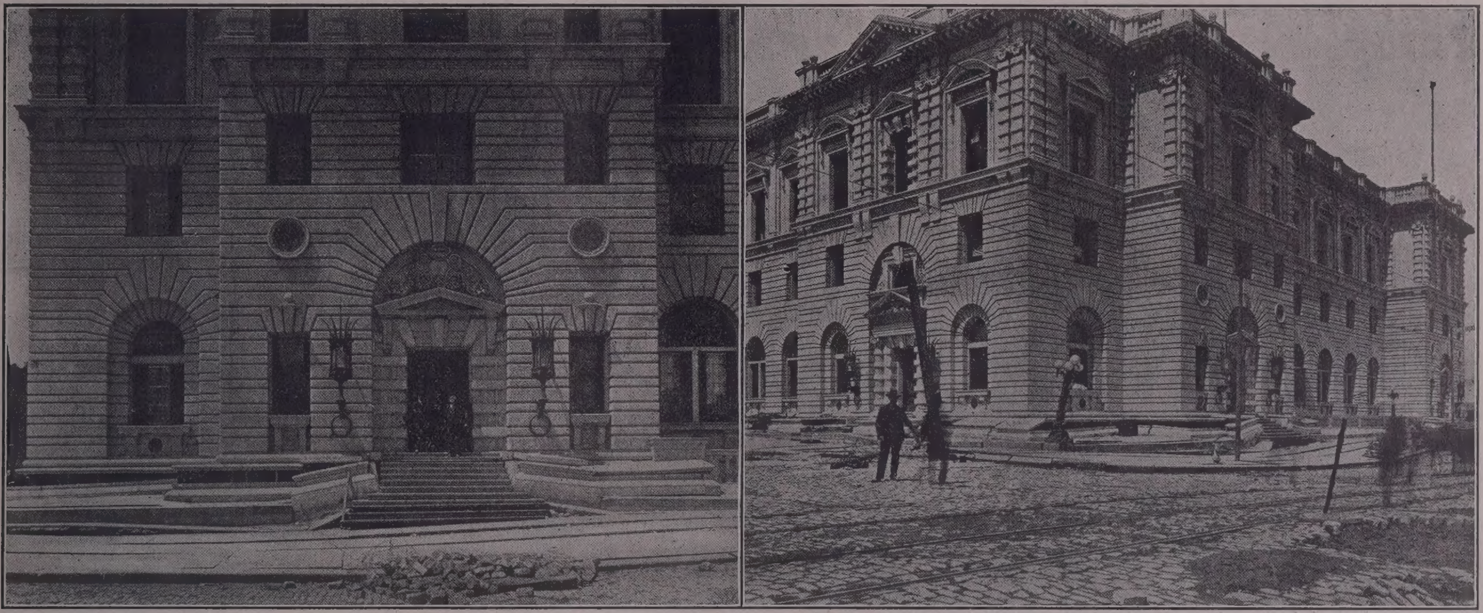
The connections for beams and girders to such a column would be made by means of brackets. While we have used columns of this type, it always seemed to the writer that as the load was transmitted primarily to the steel sections there might be some doubt as to whether or not the concrete actually would carry much load. Certainly where large sections are used it is quite reasonable to suppose that the concrete on the outside would flake off where heavily stressed unless special provision was made to hold it in place.

This office recently designed such a column for the lower story of a building in St. Paul, using two 18-in. I-beams connected with the batten plates. This design was made necessary by the owners who objected to so large a column as would have been necessary had the ordinary reinforced concrete column been used. The building department of St. Paul passed the column, allowing a stress of 350 lb. on the concrete contained between the I-beams and 12,000 lb. upon the steel. If we figure the value of the steel as ten times that of the concrete and use only the concrete confined, this concrete would be stressed to about 1,100 lb. per square inch. Another serious objection to this type of column is that if the building has beams or girders coming to the columns on all four sides the continuity of the beams is apt to be interfered with. While the column will undoubtedly carry the load for which it is figured, there is a question in the writer's mind if the steel beams will not carry most of it, as the loads are brought to them by large steel brackets.

Personally the, writer has always favored smaller members for reinforcement, such that the concrete will entirely surround and grip. There is then no question as to the steel and concrete working together and along certain well-defined lines. If, in addition, the column is hooped with a sufficient amount of steel placed in circular bonds or spirals pitched not more than 3 or 4 in., he believes the stresses in different members of the column can be much more definitely determined than in a column made up of large sections of steel imbedded in irregular masses of concrete but poorly tied together. In other words, he cannot reconcile the use of structural steel in reinforced concrete members. Any suggestions along these lines which you may care to offer would be appreciated.

Very truly yours, F. F. WELD.
Trussed Concrete Steel Co.
Detroit, May 22.

[The columns particularly referred to are reinforced by vertical angles, latticed. At a later date full details of their design and of the beam and girder connections will be published.]

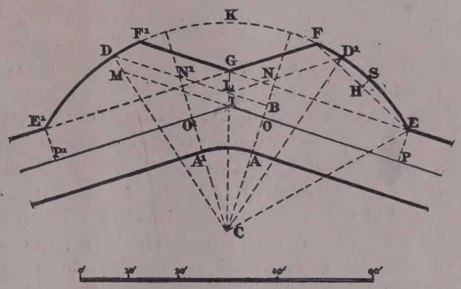


Two Views of the United States Post Office and Court House at San Francisco.

MOUNTAIN ROADS.

SIR: Early travelers over the mountain roads of the West were familiar with the sight of wrecked wagons at the bottom of canyons into which they had been upset from a badly planned turn in the road. The road makers, in haste or ignorance, had failed to regard the old, vague rule that roads should be widened at turns. The writer's attention was called to these defects when he first attempted to drive a "six line" team over a Rocky Mountain road, and in constructing a military road over the Uintah Mountains in 1882, he adopted the means described below to determine the form of the road and the exact degree of widening it should receive on turns.

It should be premised that these remarks apply to narrow mountain roads.



Mountain Road Curves.

The force of traction of a team is exerted in the direction of the pole,, which is fixed at right angles to the forward axle; the power exerted by the swings and leaders is transmitted by chains. Hence in changing direction the team should be swung, gatewise, so as to keep the pole and chains in the same vertical plane, or loosely expressed, straight; otherwise the burden would be thrown almost wholly on the wheelers. The road should therefore be of such shape and width at points of deflection as to allow the team to swing as above described; to prevent accident and to utilize the full power of traction of every animal in the team.

Let *H I H'* be the middle line of a road the *PI* being at *I* and the change of direction *M I H'* = *ACA'*. The turn begins when the front axle reaches the line *CN*, and this axle remains normal to the curve during the turn. The team occupies a position such that the off leader's head is at *D* and during the turn his head will move in the arc *D E* of the circle, the radius of which is *C D*, supposing the turn is made under the conditions above stated. Going in the opposite direction the near leader's head similarly describes the arc *D'E*.

Let C = the angle of deflection.

l = the distance from the front axle to the heads of the leaders.

W = the width of the team and wagon over all.

$C\ D = R$ = the radius of the outer curve of road.

$C\ A = r$ = the radius of the inner curve of road.

$A\ N = c$ = the width of road on tangents.

$OI = O'I = Y$ = the distance intercepted on the middle line of road between the *PI* and the limiting radii of curvature.

$N\ E = X$ = the distance between the same radii produced and the intersection of the outer curve with the outer line of the road, measured on the latter line.

Supposing the team to occupy the middle of the road, we have from the evident relations shown in the figure:

$$R = \sqrt{[r + \tfrac{1}{2}(c + w)]^2 + l^2} \ldots\ldots\ldots \text{I.}$$
$$X = \sqrt{R^2 - (r + c)^2} \ldots\ldots\ldots\ldots\ldots \text{II.}$$
$$Y = (r + \tfrac{1}{2}c) \tan \tfrac{1}{2} C \ldots\ldots\ldots\ldots \text{III.}$$

These formulas afford all the data necessary for staking out the work on the ground.

Military roads should be adapted to the standard army wagon hauled by six mules; they should allow two teams to pass on tangents—passing on sharp curves is impracticable; the width of an army wagon over all is about 7 ft. The minimum width of clear roadbed on tangents should thereupon be 14 ft. An army wagon may be driven so that the inner wheels describe a minimum radius of 17 ft.; this determines the maximum curvature of the inner edge of the road. The distance from the forward axle to the heads of the wheelers is about 13 ft.; and each additional pair adds about 10 ft. Substituting these values in equation I. we find that $R = 42.9 + 9$ or say 43 ft.

This is the minimum radius of curvature of the outer curve of the road near points of deflection. As shown in the figure there is a space *F' C F* in which neither team or wagon enters, going in either direction, and it is precisely the part where many roads are widened under the old rule to widen on turns, while the parts *G F E* and *G F' E'* are not touched. A saving in cost results by leaving the space *F G F'* where heavy cut or fill is required. Indeed the road may be narrowed to the line *D L* in case of heavy work and with safety to team and wagon, provided the necessary width be given between *D* and *E'* and *D'* and *E*.

If the width of the road be such that $r + c = R$, the team may turn through any angle of deflection within the normal width of the road. For the class of transportation considered this will be when the road is 26 ft. wide. No widening is necessary in the 14-ft. road if the angle of deflection is less than 50 deg. 26 min.

The above refers to the cases where the maximum curvature is forced on the road builder by a sharp spur or a narrow ravine. Where possible it is better to reduce the curvature. If *r* be so increased that when added to the width of the road the sum is equal to or less than *R*, no widening will be necessary on curves. Teamsters like long tangents and easy grades; they are better for the teams; and, after all, the road is built for the teamster and his team.

Another application of these principles is found also in bridge approaches. Room should be allowed for the team to complete its swing before entering the bridge.

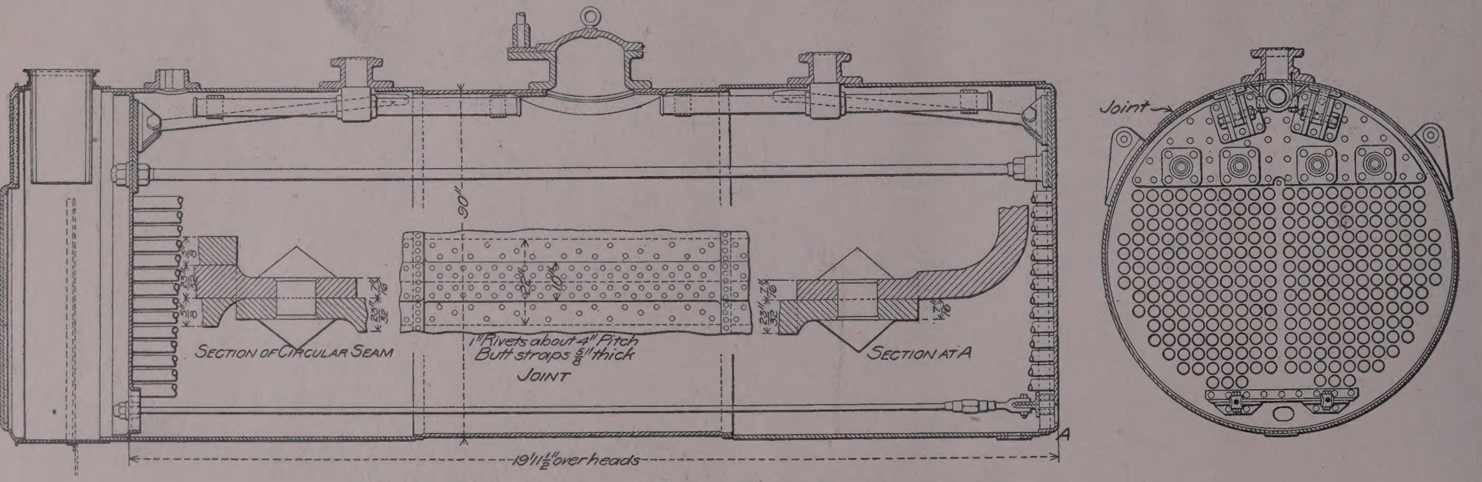
Very truly yours,

L. W. V. Kennon,

Washington, May 19. Major, U. S. Army.

Horizontal Return Tubular Boilers.

Sir: I observe in one of your most recent papers that you have an editorial on the use of horizontal return tubular boilers for high pressures, which I believe is misleading. There is enough sophistry, in my opinion, in regard to the use of water-tube and fire-tube boilers to cause a great deal of misunderstanding, especially among younger engineers, many of whom seem to hold the idea that there is no merit in anything except water-tube boilers. I am one of those persons who believes that a horizontal return tubular boiler or almost any other internally fired boiler is better from any point of view than any water tube boiler, and the following paper contains some of the important arguments in their favor.



General Details of a Horizontal Tubular Boiler for High Pressure.

"It has been thought by many persons that the thick plates necessary for high pressures with this type of boiler are a source of danger on account of possible overheating. An examination of the theory of the transmission of heat through steel plates will show that their capacity to transmit heat is scarcely affected by any probable thickness that will be used. The resistance to the transmission of heat from a fire to the water in such a boiler is chiefly due to the soot on the outside of the boiler and dirt on the inside. An accumulation of soot on the outside is a protection to the plate from overheating wherever there is dirt on the inside, for obviously it diminishes the amount of heat that enters the plate.

"In 1890 an important paper was read before the North East Coast Institution of Engineers and Shipbuilders in England, by W. Kilvington and Alex. Taylor, on the use of thick plates for the furnaces of marine boilers. It had been for many years held that ⅜ in. was the greatest advisable thickness for such furnaces. This, after a few years, was increased to ½ in., and in 1890 few engineers objected to furnaces ⅝ in. thick. Similar changes in opinion on this subject have taken place in regard to the thickness of plates of horizontal return tubular boilers.

"The writers of the paper referred to state that they know of no furnace that has collapsed from being too thick. Cases of collapse have always been due to oil and dirt accumulating on the furnaces, and this is the only cause of a horizontal return boiler bagging on the bottom. It is also the cause of bagging and explosions of the tubes of water-tube boilers. In 1890 there had been furnaces at sea for three or four years ¾ in. thick and subjected to 160 lb. pressure without failure. The writers of the paper have investigated the resistance offered by a ¾-in. plate over a ⅝-in. plate and find it only 1 per cent. They recall that this was long ago known by Rankine who wrote: 'The external thermal resistance of the metal plates of boiler flues and tubes, and other apparatus used for heating and cooling fluids, is so much greater than the internal thermal resistance, that the latter is inappreciable in comparison; and consequently the nature and thickness of those plates has no appreciable effect on the rate of conduction through them.'

"In 1867 Mr. Isherwood made some experiments on the transmission of heat through plates varying from ⅛ to ⅜ in. in thickness, a variation of 300 per cent. where one side was exposed to steam and the other side to water, and he states that the difference in thickness did not measurably influence the result.

"Messrs. Kilvington and Taylor decided that they would not hesitate to use plates of marine furnaces 1 in. in thickness. They also conclude that the same amount of scale and dirt will cause a thin plate to collapse as soon as a thick plate. In this country corrugated furnaces in the Vanderbilt locomotive boiler have been made ¾ in. thick without trouble, and to carry, I believe, 200 lb. pressure.

"All of the above reasoning applies to horizontal return tubular boilers, and the only inference to be drawn from it is that safety and efficiency are not to a measurable extent affected by an increase in the thickness of plates. Already there have been built from a design by the writer, two 90-in. boilers with plates 23/32 in. thick to carry 165 lb. of steam, and he would not hesitate to use plates 15/16 in. in thickness for this size of boiler to carry 230 lb. pressure.

"A pressure of more than 150 lb. of steam for land service is very uncommon, and the builders of the most prominent steam turbines apparently do not care to use more than this at present. As 78-in. horizontal tubular boilers are as large as are usually required, a boiler of this size for 150 lb. of steam would be 17/32 in. thick or only 1/32 in. over ½ in. As ½-in. plates for this type of boiler have been common for many years, it will be seen that there is no risk in using this size for 150 lb. pressure. For 175 lb. the thickness of plate would be ⅝ in., which has been used several times, and for marine furnaces many times without trouble. For 225 lb. the plate would be 13/16 in., which is but slightly thicker than 23/32 in. referred to above, which, after one and a half years' use, has caused no trouble.

"With plates as thick as ⅝ in. or more, where they lap and form the circular joints there is a double thickness which is considerable. This is easily overcome by planing down the brakes where they lap. This does not apply to the longitudinal joints, as they are above the fire surface. Planing the plates for the circular joints does not weaken the boiler because the circular joint is strained but a trifle. Any thickness that can be caulked is ample to stand the stress from pressure, and in general it can be said that the plate can be planed to a thickness of 7/16 in. or to ⅜ in., no matter what the thickness of the body of the plate may be. With this refinement carried out, no difficulty from thick plates will occur, and boilers of this type can be confidently used for any pressure that is likely to be demanded for many years to come. It may be even unnecessary to thin down the plates at the circular joints, but this is an advisable precaution.

"Inasmuch as the horizontal return tubular boiler when built with butt longitudinal joints has proved itself to be the safest boiler that is prominent in this country; since there has been but one explosion of such a boiler, it would seem to be the safest type for higher pressures than have heretofore been used. Occasionally engine and turbine installations may cause a demand for boilers carrying 200 lb. pressure, and the horizontal tubular boiler will meet this demand."

I enclose a drawing of a large horizontal return tubular boiler designed for 165 lb. pressure, which has been in use several years without trouble. I should add, however, that the boilers have not so far carried over 140 lb., but they are to carry 165 lb. shortly.

Yours truly, F. W. Dean.

Boston, May 19.